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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Welsh Engineers' and Founders' Association.
Secretary: F. J. Griffiths. 20. Fisher Street Swansea.

Forthcoming Events.

Institute of British Foundrymen.

DECEMBER 16.

London Junior Section:—Ordinary meeting at 49, Wellington Street, London, W.C.2. "Continental Foundries," Paper by V. C. Faulkner.

DECEMBER 17.

Lancashire Branch (Junior Section):—Ordinary meeting at Manchester. "Selected Moulding Jobs," Paper by E. Longden.

Scottish Branch (Falkirk Section):—Ordinary meeting. "Recent Foundry Developments, with Special Reference to Poumay Cupola," Paper by J. Cameron.

Instalment Buying and the Basic Trades.

The business man, observing the rapid growth of instalment selling on the lines so popular in America, is apt to dismiss it from his mind as a social phenomenon that is unlikely to affect him very closely. But the issue involved does not in fact concern business and industrial interests intimately.

Hire-purchase has flourished for a long time among the working classes, who, being little able to protect themselves, have yielded big profits at a time when the nature of the system was somewhat more dubious than it can fairly be said to be to-day. Moreover, it is considered perfectly respectable in any rank of society to buy your house by a modified form of hire-purchase, and an exception is likewise made for motor-cars. Sewing-machines, pianos, and refrigerators are gradually conceded to the credit salesman, and, judging by the rapidly-expanding volume of advertisement on the subject, we in this country shall very soon be in the same position as our American cousins, who habitually buy their clothes, furniture, jewellery, wireless, and domestic appliances of all sorts out of income.

What instalment buying amounts to is this. The man who buys in this way is buying an article, the capital cost of which will necessitate saving, only he is buying it before instead of after the act of saving. In other words, he is pledging in advance a fixed minimum surplus of income over expenditure. What would he have done with that surplus had there been no convenient firm ready to deal on these terms? If he is in the category of the newly-married man furnishing to set up house, he would still have spent the money on furniture, but he would have received his money's worth in furniture instead of partly in furniture and partly in financial accommodation, and so in the end a greater part of his saving would have found its way into industry. If, on the other hand, he is tempted in this way to the advance spending of a surplus that would otherwise have been invested, industry stands to lose still more.

For in effect the purchaser borrows from the vendor the purchase price of the goods he obtains *less* any deposit he may pay at the time of the transaction. The difference between cash price and credit price is usually kept discreetly in the background, but it does in effect represent the interest exacted on the loan. The question arises whether the interest charged thus, in the shape of an uneconomically enhanced price, is fair return for risk involved, or whether it is an unreasonable diversion of the spender's surplus into the pocket of the middleman instead of into productive industry. The rapid growth of the business suggests large profits, and large profits suggest that the second alternative is actually the case.

The effect on industry is twofold. There is first this diversion of surplus income from productive to unproductive objects that inevitably follows on the financial accommodation which instalment selling in fact affords, and the interest charged on it. Secondly, in so far as the buyer pledges his surplus in advance he is giving to industry an artificial stimulus—his demand is backed by no power to pay cash, and in a period of falling prices and wage-rates the production of this vast mass of goods unpaid for, and unlikely to be paid for, would contribute very materially to a disaster in which the basic industries would inevitably be involved. Whatever might be said of the back-street salesman of a decade ago, the modern instalment seller expects to make his profit, not on the unpaid-for goods that he confiscates, but on the paid-for goods for which he receives interest. At a time of declining trade, therefore, he would be in the position of any merchant who is left with vast quantities of unsaleable goods on his hands, and the further the hire-purchase system be pushed the greater the danger it presents in the event of a slump.

Over and Under.

We learnt with a certain amount of concern that the Right Honourable Arthur Henderson and Mr. J. T. Goodwin, the President of the Institute of British Foundrymen, both thought it necessary to warn foundrymen against over-mechanising British shops. Our concern is not for the erudite but for the less-enlightened members of the industry, who will see in these statements a solid peg upon which to hang their hats of either retrogression or stagnation. They base their warning on the assumption that specialised quantity production methods stifle initiative, considerably reduce, if not exterminate, the demand for skilled artisans, and generally decolorised industrial conditions. Exactly similar arguments were probably put forward when power-driven machinery first became a potent factor in industry. It has cropped up in recent years whenever standardisation is discussed. In this case, however, there is a difference; the gentlemen referred to did not warn us against mechanisation, but *over-mechanisation*. All these questions are inter-related and are covered by the now much-used word "rationalisation." If we were asked to define the modern conception of this word, we believe we would submit the following: "Massed clear and logical thought for the promotion of progress in industry." Thus *over* production, *over* staffing, *over* mechanisation, and all other *overs* immediately require attention, as is obviously the case with "*unders*." At the moment "rational" thought seems to our mind to indicate that it is the "unders" that require the urgent attention of British foundry owners. *Under* mechanisation, *under* production, *under* profits, *under* exports, *under* payment from directorate to skilled artisan are matters of real urgency. Mr. Henderson, in the speech at the London foundrymen's annual dinner, also stressed the importance of co-operation, and emphasised the safeguarding of the third partner—the consumer. We insist that a rich man, or a rich industry, can do more for the consumer than a bankrupt, and "rational thought" tells us that as an industry the foundry trade must become more opulent. The only means is by co-operation of every interest concerned to avoid waste of energy, money and material. This waste must be transferred from the *over* to the *under* side.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Spanish Railways.

To the Editor of The Foundry Trade Journal.

Sir,—I was very pleased to see Señor Rubio's reply to the adverse description of Spanish railways contained in the Random Shots column a while back.

A year or two ago I spent two months in Spain on business and had occasion to use the railways very considerably, and apart from certain narrow-gauge lines, the service leaves nothing to be desired.

In one respect they are ahead of British railways inasmuch as there is no overcrowding, tickets only being sold to the limit of the seating capacity of the trains.

I can fully endorse all your correspondent has to say of Barcelona and I am looking forward to re-visiting that city for the Foundry Congress.—Yours, etc.,

T. H. Gray.

119, High Holborn, London, W.C.1.

[We have received other complaints from various semi-official Spanish authorities. We repeat our apology, but would remind readers that, after all, Random Shots is written in the lighter vein.]

Hot Blast Cupola Yields 20 Per Cent. Fuel Economy.

Mr. F. K. Vial, writing in "The Iron Age," states that the Griffin hot blast cupola (a modification of the Schurmann system) has now been in continuous operation on the production basis for two years. In the meantime 200,000 tons of iron has been melted by this process and poured into car-wheels, with a loss of less than one-half of one per cent. for chill variations, which is a remarkable performance. The economy in fuel and the added control of cupola conditions have been thoroughly established. Fuel economy of 20 per cent. may ordinarily be expected. The fact that there is 20 per cent. less air to be driven through the cupola and that the pressure is only one-half the amount required in ordinary cupola practice ensures a power economy of considerable magnitude, especially where high blast pressures have been used.

A saving in labour arises from the fact that there is less coke to be unloaded and made up into charges and the larger iron charges result in fewer trips of charging buggies.

The increased control of melting conditions is an important factor where the resultant product is dependent upon the uniformity of the character of the molten iron, such as is required in chilled iron products.

The price of coke per ton ranges from $10 to $15 or from ½ c. to ¾ c. per lb. The saving of 60 lbs. of coke per ton of iron melted therefore represents a saving of fuel of from 30 c. to 45 c. The present consumption of coke in the American foundry industry is upward of 1,500,000 tons per annum, which, including the cost of handling, represents a cost of $20,000,000. Twenty per cent. of this, or $4,000,000 could be saved annually by the use of the hot blast cupola, to say nothing of the reduced power requirements for driving the blast.

American Foundry Equipment.—The association taking care of this industry reports a falling off in orders in September, the index figure being only 80.4, compared with 132 for the first nine months of the year. The basic figure of 100 was arrived at by averaging business over the three years, 1922, 1923 and 1924.

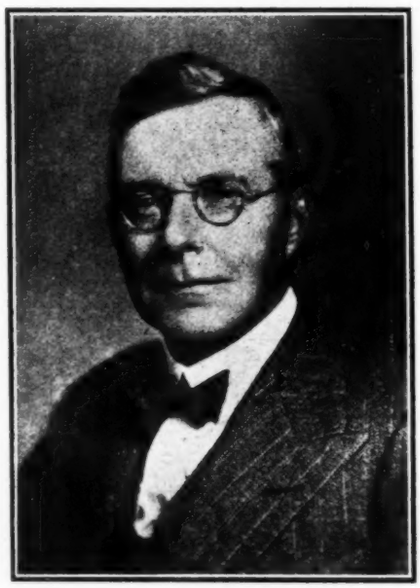
St. Dunstan's.—It is always a satisfaction to be able to draw attention to the annual report of St. Dunstan's, and this one, the 12th, includes an actuarial report as to the requirements for the future welfare of war blinded soldiers. This is a phase which will be appreciated by business men subscribers, who, we feel sure, will see that future requirements will be forthcoming.

I.B.F. Branch Presidents.

No. 8.—The London Section.

Mr. W. B. Lake was educated at Witham and in Germany. He served a five years' apprenticeship to his father's firm, Messrs. Barnard & Lake, of Rayne, who were agricultural engineers. At the age of 21 Mr. Lake was appointed works manager, and held this position for several years, and during this time patented a number of inventions. The business then changed hands, and with the capital derived from the sale of his patents he started business for himself with one man and a boy making agricultural machines and tools for cycle repairing. Three years later he was joined by Mr. Elliot, and the firm of Lake & Elliot was established.

This company now employs 700 people and makes parts and accessories for motor-cars and manufactures grey iron, steel and malleable iron castings and furnishes electrical energy to the surrounding district.



Mr. W. B. Lake.
(*President of the London Section of the Institute of British Foundrymen.*)

In 1905 his firm bought a German process for the production of mild steel castings from crucibles, and were the first British company to make them successfully commercially. In 1910 he installed the first electric furnace in Great Britain for making steel castings. In 1924 the firm commenced the production for the first time in this country of blackheart malleable iron castings from the electric furnace. Mr. Lake's firm was also the first steel foundry in Great Britain to instal the sand slinger and plant for the renovation of moulding sand. In the early days of the war, at the request of the Government, Mr. Lake restarted the National Steel Foundry of Leven, Fife, and equipped it with electric furnaces and a machine shop for turning wheels, and it was here that a large proportion of the road wheels used for mechanical transport during the war were made. After the war he relinquished his interest in that company.

The Pneumatic Engineering Appliances Company, Limited, of Donnington House, Norfolk Street, W.C.2, have received repeat orders for the improved "Peacolt" moulding machines from the London & North-Eastern Railway (five machines); the London, Midland & Scottish Railway (eight machines); Hurst, Nelson & Company, Limited, Motherwell (three machines; Linotype & Machinery, Limited, Altrincham (two machines); the Birmingham Railway Carriage & Wagon Company, Limited (three machines); and Messrs. Henry S. Potter, Limited, Johannesburg (two machines).

Random Shots.

Lord Aberconway's recent book on the "Basic Industries of Great Britain" is a mine of interesting and authoritative information. It is certainly a shade overloaded with figures, but no one will quarrel with that. Too many authors, even in the technical field, content themselves—and most emphatically fail to content their readers—by falling back on vague generalities and delightful ambiguities at the very point where precision and illustration are most required. Here, on the contrary, we are given in almost wearisome detail the constitution of the board of directors, the amount of capital, number of employees, etc., whenever a firm of any importance is mentioned. It is not information that is inaccessible to the general public, but it is information that the general public rarely takes the trouble to look up for itself.

* * *

As a matter of fact, one is tempted with a book of this kind to wonder whether figures in bulk are ever agreeable reading unless you are a mathematician or a statistician. . . . The body of the book in question gives the facts and figures as part of the text, and to come across whole pages of this type of matter puts a severe strain on the reader's power of concentration. On the other hand, if we turn to the appendix we are faced with rows of orderly tables. Reflecting that this, after all, is the way to present figures, we proceed to glance them over . . . . but the untrained eye baulks at tables, however orderly, and beyond a general impression of relative sizes and quantities a first perusal is apt to leave a very hazy impression, indeed. . . .

* * *

Not that Lord Aberconway does nothing for us beyond dishing up quantities of figures in a variety of ways; he introduces much descriptive and historical matter, and he draws conclusions which, if they are not novel, are at least emphatic and authoritative. Broadly speaking, he suggests that there are three roads along which we may look for industrial recovery—scientific research, reduction of manufacturing costs, and improved selling organisation abroad. He deals at some length with the first two of these points, but the last of them is passed over briefly.

* * *

How nice it is to be assured that business is looking up for someone, even if it be only the Christmas card maker and the producer of crackers and toy trains! True, darkest depression will again engulf them in a few weeks, for the market value of a 1927 Christmas card is, after all, negligible in the early days of 1928—but for the moment all is happiness!

* * *

Indeed, it seems a pity that our own advertisers do not take a lesson from their brethren in other fields, and endeavour to impress upon us the gift possibilities of their wares. The dullest and most prosaic of retail establishments discovers some item in its stock-in-trade that can bear the strain of Christmas boosting—why not extend the principle to the wholesale world in general, and the foundry world in particular?

* * *

No one, for instance, has yet exploited the gift possibilities of a special line of foundry blacking, done up in fancy bags with seasonable labels . . . nor the attractive powers of a novelty in Christmas ladles, specially gilded and tied up with ribbons . . . nor yet the potentialities that lurk in a special offer to every purchaser of a truck-load of moulding sand before the 25th inst. of a particularly handsome truck free, gratis, and for nothing (except, of course, a little matter of some 50 per cent. on the usual price, which, it may be assumed, the customer will be much too dazzled to notice. . . .).

* * *

Of course the real drawback is that the people we usually honour with our Christmas gifts seem to have an odd predilection for motor mascots and tobacco jars, and chocolates, and Parisian dolls, instead of having the sense to want something that might help business a little. . . .

Marksman.

Institute of British Foundrymen.

LONDON BRANCH DINNER.

The occasion of the Annual Dinner of the London Branch of the Institute of British Foundrymen, held at the Engineers' Club, Coventry Street, Piccadilly, W.1, on December 9, under the Presidency of Mr. W. B. Lake, J.P., was a memorable one not only because the gathering constituted a record in numbers—there were 94 members and guests present—but also because of the distinguished guests who had accepted the invitation to attend. The company included the Rt. Hon. Arthur Henderson, P.C., M.P., Mr. J. T. Goodwin, M.B.E. (President of the Institute), Sir William Larke, K.B.E. (Director of the National Federation of Iron and Steel Manufacturers), Mr. V. G. Crittall, M. Montfort (President, French Chamber of Commerce), Mr. V. C. Faulkner (Past-President of the Institute and of the London Branch), Captain Crewdson (Industrial Newspapers, Limited), Mr. Barrington Hooper, C.B.E. (Industrial Newspapers, Limited), Mr. J. Cameron, J.P. (Past-President of the Institute), Mr. James Ellis (Past-President of the Institute), Mr. K. W. Bridges, Mr. H. N. Davis (Chairman of the Davis Stove Company), Commander Withers, C.I.E., R.I.M., Mr. J. G. Pearce, B.Sc. (Director, British Cast Iron Research Association), Mr. Wesley Lambert (Past Branch-President, and Vice-President of the Institute), Mr. J. H. Booth, Mr. F. Perkins, Mr. H. G. Sommerfield (Branch Hon. Secretary and Treasurer), Mr. A. R. Bartlett (Past Branch-President), Mr. H. O. Slater (Past Branch-President), Mr. G. C. Pierce (Past Branch-President), Mr. J. W. Gardom (Branch Vice-President), and Mr. A. S. Beech.

Mr. Henderson on Need for Science

The Loyal Toasts having been duly honoured.

The Rt. Hon. ARTHUR HENDERSON, P.C., M.P., proposed "The Institute of British Foundrymen," and coupled with the toast the name of Mr. J. T. Goodwin (the President). In the first place he recalled the fact that when, eighteen months previously, he had officially welcomed the Institute to London, he had remarked that he failed to see the appropriateness of his having been invited to take part in the ceremony. On that earlier occasion he had been created an Honorary Member of the Institute, however, so that he could not plead that he failed to see the appropriateness of his having been invited to attend the annual dinner of the London Branch, for, he said, "I am one of you." He had been told that the Institute was entirely non-political. Its members were a strange lot of non-political people who, twice in eighteen months, had invited "one who had had some slight association with politics" to be their guest. He was not quite sure that they realised the responsibility they had taken upon themselves by so doing. It was said of the establishment with which he had been associated for over 24 years (the House of Commons) that each day, when the House opened, the Chaplain had a good look at his audience and proceeded to pray for his country. (Laughter.) There were one or two of the objects for which the Institute stood, however, which commended themselves to him. Apart altogether from politics, and apart altogether from the fact that this was the second occasion on which he had attended a function of the Institute, he had had some "remote" connection with the foundry. (Laughter.) Some 52 years ago he had had to decide that he would put in a little time at work, and he had selected an iron foundry as the scene of his activities. For some 16 or 17 years he had moulded castings. Referring again to the activities of the Institute, he said he had noticed that it sought to promote the well-being of its members by assisting them in several ways. It concerned itself with the academic, the scientific and the practical affairs of the founding industry. It was not content to get its members to a certain position and leave them there; it was always seeking, by different methods, to improve their intellectual position. One of the things that had impressed him most was the practice of exchanging Papers, and the interchange of visits to different countries. There was nothing so informing as travel. Recently he had travelled round the world; he had visited Canada, Honolulu, Fiji, New Zealand, and every one of the States in Australia, and the new capital of the Great Australian Commonwealth, Canberra. That was one of the privileges of a very long public life. When he had heard of the Institute's efforts, especially the exchange of Papers between this and other countries on subjects appertaining to the industry, he had felt that nothing but good could come out of those efforts. Indeed, it was essential that such work should be carried on. If he might be permitted to give a word of advice, especially to the young men—and he had been remarking on the large number of young men present—he would urge them never to come to the conclusion that their period of learning had terminated. Michel Angelo, in his eighty-third year, had said of himself, "I am still learning." That was a spirit which ought to dominate every member of the Institute. And why was it so essential that this learning should continue? Those who had taken more than a passing interest in trade affairs must know that this country of ours, formerly the leading manufacturing country of the world, had competitors growing up on the right and on the left. One had only to visit the United States of America, as he had done two years ago, in order to appreciate what we were up against. He did not suggest it was something we were illegitimately up against; we were quite legitimately up against it. If any of his hearers could pay a visit to the great works of Mr. Henry Ford, at Detroit, as he had done, and could see how science had been applied to the founding industry there, he ventured to say they would come to the conclusion he had reached, namely, that it was quite impossible for those associated with this important industry, whether in its management and direction, or whether in the carrying out of the practical work of production, to know too much if this country were going to occupy its position much longer as one of the great competing nations of the world.

Hindering Progress.

He could tell of his association with the industry in this country at a time when that lesson had not been learned. He was not going to say that things remained to-day quite as they were before the war, for the war had taught us lessons which we ought never to forget. It was not so many years before the war when he had visited one of the greatest manufacturing establishments in this country as a delegate of the workers to deal with a difficulty which had arisen. On the evening before his visit to the works he had visited the branch of the Union concerned and had discussed the matter—because he always liked to hear all about these matters at first hand. One of the things he was told was that quite recently the firm in question, in order to encourage new and improved methods of production, had published notices inviting suggestions from the practical men in the foundry to this end. But the results were not what they should have been. When he had visited the works next morning the Managing Director had received him very cordially, and they had had a very interesting discussion of their respective difficulties. The Managing Director had said that he had invited suggestions with a view to bringing about more expeditious and more efficient production, and had offered rewards for suggestions accepted. He (Mr. Henderson) had replied that he was delighted to hear it, but, he had pointed out, what happened in practice was that when a man made a suggestion, his foreman came along a day or two afterwards and said: "You had better take care, or your name will be Walker." That foreman, said Mr. Henderson, had not learned the lesson; as an official he was not promoting the interests of his firm, but was hindering production and discouraging the men under him. As a result of the interview, however, the Managing Director had made inquiries, and with a very definite result.

American Craftsmanship.

Referring to trade, Mr. Henderson said that for the last five or six years we had been passing through a very critical period in this country. He did not think he need pause to attempt to allot the blame, for he doubted very much whether recrimination in these matters, either on one side or the other, would lead us very far. The wiser plan was to recognise that things were not as they ought to be, and for those on each side to examine themselves and to ascertain whether, after all, some of the responsibility did not rest with them. While trade had been in a most unsatisfactory condition for a very protracted period, however, there was some indication of improvement. But even if there were not such indications, he could not for a moment accept the conclusions that some had reached, namely, that this good old country of ours, from the business standpoint, was obsolete and done for. We had craftsmen, technicians, and, he hoped, management equal, if not in all cases, at least in some, to anything in any other country in the world. Those who had had any association with the British workman would agree that from the point of view of craftsmanship there was no one to beat him the world over. Indeed, he (Mr. Henderson) was prepared to say that, taking the next two decades, he would back the English craftsman against the American craftsman at the end of the second. One of the things which he had disliked particularly in the great manufacturing centres of the United States was that they had over-mechanicalised; they had made the human machine subordinate to the machine itself. They had so applied science to manufacturing processes that the man ceased to be a craftsman, as we understood the term. In the assembly works at Detroit he had seen a bare frame placed on a moving platform and moved along, almost at a snail's pace, between two rows of workmen. One part after the other was put together as it moved along with the platform, until eventually it became a complete car, and he had seen the lights tested and the car driven away from the works. He had seen one man standing in one spot all day waiting for the car on the platform to reach him, and all he did was to turn two or three screws; that was his day's work. Further down a man was sitting down and holding a large, broad brush, such as might be used for whitewashing a ceiling. With this he painted the bodies of the cars as they passed. He drew the brush across the car about three times, and that was all the paint it got. The effect of all that was to destroy craftsmanship; it was specialisation gone mad, almost, or the substitution of specialisation for craftsmanship. He had said to the manufacturers in America that they were certainly getting production, but what the position of the men would be twenty years hence he hesitated to suggest.

Tripartite Responsibility of Industry.

The Institute of British Foundrymen, in his opinion, was going to be a powerful factor in preventing too great a tendency to specialisation in this country, such as had occurred in the United States; at any rate, he hoped so. He hoped we were going to retain our craftsmanship, that we were going to have a higher standard of efficiency so far as the technical work was concerned, and that the management, as the result of the retention of our craftsmanship and of our higher standard of technical knowledge, would deal with our industrial problems so intelligently that our men would be able, for many years and many decades to come, to maintain for this great old nation one of the foremost positions among the nations of the world. He hoped we should realise co-operation in its truest sense, co-operation by which we meant all for each and each for all. One of the disappointing features in connection with industry since the Armistice was that many of our men, having served in the trenches and realised a brotherhood and a comradeship absolutely unknown before, and having believed that that comradeship of the trenches would eventually be translated into the fellowship of industry, had suffered disillusionment. We must assist in dis-

pelling that disillusionment. We must bring back the real spirit of co-operation, because co-operation, in his judgment, was the key to industrial progress. Mr. Hoover, of the United States, had put forward some magnificent ideas at a conference organised by the National Civic Federation of America, formed to effect through educational conferences the elimination of industrial waste and the minimisation of industrial strife. He had said, "Industry was coming into a tripartite responsibility to consumer, worker and capital. Labour's interest in its responsibility for the functioning of the whole economic machine was growing. The fund from which Labour must expect the maintenance of the present wages, or an increase in real wages, lay in more efficient production and the elimination of waste." He had also said that an astonishing proportion of America's national production, especially in the older large manufacturing companies and public utilities, was now operating in various degrees under the regime of the new conception of capital, management, labour, consumer. He would not be surprised to find a considerable majority of "big business" now evolving into this field. That, said Mr. Henderson, was the correct idea. One of the things that had impressed him for a good many years was that when, unfortunately, industrial strife overtook us in this country we seemed to forget that there was a third party concerned. We had Capital arrayed and highly organised on the one hand, and Labour arrayed and highly organised on the other. They fought with tenacity and with unyielding purpose almost as long as human endurance was capable, but during the whole process the fact was that the greatest partner, and oft-times the greatest sufferer, namely, the great British public outside the arena—the consumer—was suffering more than all. He wanted to see that form of co-operation which would have some regard and some deep concern for the welfare of the great mass of the people. If we achieved that form of co-operation we need never fear that Great Britain had become effete, or that she was deteriorating to such an extent that she would never recover. If we would pull together in this spirit he ventured to say that we should be able to look our competitors, whether they be in the United States, in Germany, or wherever they be, in the face, and say that we would pit our craftsmen and our technicians and our management against anything they had got, and that we would stand by the results. Finally, Mr. Henderson asked the company to drink to the health and permanent success of the Institute of British Foundrymen, and coupled with the toast the name of Mr. Goodwin, its President.

Mr. J. T. Goodwin, M.B.E., M.I.Mech.E. (President of the Institute), responding, said that the sentiments expressed by Mr. Henderson, coming from one who was not a layman in the foundry business, went very deeply into the hearts of his hearers. They realised that Mr. Henderson had been "through the mill," and had attained a position which only a man of his calibre could attain, and they all had a very affectionate regard for him. He himself was suffering that evening from a flick over the face with a very keen whip, though it was a kindly flick. It was the realisation that we did not blow our own trumpet hard enough. We listened to those who lauded to the skies the abilities of others, even to our own detriment, but we had still a lot to be proud of in this old country. He could safely say to Mr. Henderson that the members of the Institute were doing their best to co-operate in the true sense of the word. For example, there was the interchange of papers that took place, not only between this and other countries, but between the various local sections of the Institute; there was also the fact that the number of visits to works was increasing yearly, and more doors were thrown open than had been the case before. He was sure that the activities of the Institute which had resulted in the formation of the British Cast Iron Research Association would meet with Mr. Henderson's approval. That Association had been a real success, and the Government had recognised its worth, after its first five years of work, by continuing to support it for another five years.

Ford's Losses.

We in this country, by the combination of science and practical work, had achieved much already, and Mr. Henderson had paid this country one of the greatest compliments he had ever paid it when he had emphasised that British brains were not dormant, and that the skill of this country was growing greater and greater every day, under scientific management. Mr. Henry Ford had been frank enough to acknowledge publicly within the last few days that he had lost £20,000,000 in his effort to regain the world markets, and especially the market of this country. In spite of that expenditure by Mr. Ford, we had been able to drive his car clean off the English market with a car which was far superior and equally as cheap. It was a great credit to us that we had been able to do it, and he begged of those in the foundry industry to maintain the spirit of co-operation of which Mr. Henderson had spoken so eloquently. He also urged those concerned with the management not to over-mechanicalise, but to give the men an interest in the future, to let them see an opportunity for promotion in the distance, so that they would realise that they too had something to grasp. As another example of the fact that co-operation did exist in the foundry trade, the President referred to the Foundry Trade Journal, which, he said, was doing a vast amount of work, and was responsible for carrying out more propaganda than could be carried out in any other way. In that organ there was co-operation and team work which was recognised by all. The members of the Institute supplied valuable scientific papers, which the Foundry Trade Journal published and spread amongst the whole of the Branches. Speaking of the Branches, the President said that the Members of Council were delighted with the vast improvement that was taking place, especially in the London Branch. Since Mr. Faulkner had first taken hold of the Branch, as its Secretary, it had commenced to grow tremendously, and when he had handed over the reins to the present hard-working Secretary, Mr. Sommerfield, it had continued to grow.

South of England Foundry Development.

Mr. H. N. Davis (Chairman, Davis Stove Company), proposing "The London Branch and its President," said he had learned that the boundaries of the Branch extended as far north as Halifax and as far south as Southsea, and even to Torquay, for it had members in those distant towns. In addition, it had many members in countries outside Europe. One wondered why the London Branch had spread its tentacles so far afield, and he believed the explanation was the great attraction of the Branch by reason of the enthusiastic interest of its members in all matters—scientific, technical and practical—connected with the good old founding industry, not to mention the facilities it afforded for friendly intercourse between those who were interested in and whose livelihood depended upon the success of that industry. The Secretary had suggested that a fitting alternative title for the London Branch would be the "Magnet" Branch, and, judging by the way in which the members from distant towns were drawn to the meetings, that title would appear to be a very appropriate one. The membership of the Branch was in the region of 250, and that in itself was a tribute to its popularity. Two members of the Branch—Mr. Faulkner and Mr. Ellis—had occupied the Presidential Chair of the Institute, and he was sure there were others well worthy of that honourable position. There were still a good many people who associated foundries with the North of England and Scotland. A very great change had taken place in the industry in the last two or three decades, however, especially in the light castings section, and there had been an enormous development in the Midlands and the South of England—a fact which was evidenced by the increasing membership of the London Branch. In a tribute to the Branch President, he said that the splendid atmosphere of enthusiasm, interest and goodwill emanated very largely from him. Mr. Lake was an enthusiastic foundryman, who had the interests of the Institute, and perhaps more especially of the London Branch, closely at heart. He was known to the foundry industry in almost every country in Europe, and was one of the most energetic members of the party which had toured America last year. The members of the Branch were very fortunate in having Mr. Lake as its President.

The Forthcoming International Conference.

Mr. W. B. Lake (the Branch-President) spoke first of the pride of the members of the Branch in having Mr. Henderson with them at their annual dinner. The opinions Mr. Henderson had expressed, he said, were cordially endorsed by all those present. One of the reasons why they were so pleased to have him with them was that he had the great gift of being able to express lucidly those things which they themselves could only feel. Another reason was that he was an outstanding example to foundrymen, and especially to young foundrymen, of the heights which the possessor of ability and integrity could reach. The members of the Branch were also delighted to welcome the President of the Institute, as well as the Past-Presidents who were present. The Branch-President expressed indebtedness to Industrial Newspapers, Limited, for the very great assistance they had always rendered to the London Branch. Ever since he had been a member, the Branch had to a large extent leaned on Industrial Newspapers, Limited, and their predecessors, and the members were delighted, therefore, to see two of the directors—Captain Crewdson and Mr. Barrington Hooper—present, so that they might express appreciation. The London Branch had a great work ahead. All their energies were concentrated on the International Convention, which was to be held in London two years hence, for upon the Branch had devolved the duties of hosts to those who would then be visiting this country. A number of them had had the privilege of attending the last Convention, held at Detroit, when our American friends had set a standard which would be difficult of emulation in the way in which they had organised the Convention, and in their unbounded hospitality. It was the duty of the members of the London Branch to try to return that hospitality to the utmost, and, fortunately, they were well on the way to be able to do it.

Steady Growth.

At the time of his election to the chair he had made a special appeal to members to increase their numbers, so that the Branch might be strong enough to undertake the great work which lay before it, and the response had been remarkable. As a result, the Branch was very nearly the largest in the country, and it intended to be the largest by the time of the Convention. The bulk of the work would fall upon Mr. Sommerfield, the Branch Secretary, and upon Mr. Bridges, whose task it would be to organise the foundry exhibition to be held at that time. In a tribute to Mr. Sommerfield, he said he had never met a more capable Secretary, or one who stood higher in the estimation of his fellow-members. Another matter to which the Branch-President referred was the work of the Junior Section of the Branch, with a membership of 18, and in this connection he paid a tribute to Miss M. Pittuck its Secretary, on whose behalf he appealed for even greater support by inducing young moulders to join.

Mr. Wesley Lambert (Vice-President of the Institute, and Past-President of the Branch) proposed the toast of "Kindred Associations," to whom, on behalf of the Institute, he expressed indebtedness for their sympathy and kindness, and particularly for the valuable information which emanated from them, in the form of technical papers, which were of considerable use to foundrymen in general. The representatives of the kindred Associations included Mr. J. Cameron and Mr. H. N. Davis (National Light Castings Association), Mr. J. G. Pearce (Director, British Cast Iron Research Association); Mr. A. H. Mundey and Mr. Griffiths (London Local Section of the Institute of Metals); M. Montfort (French Chamber of Commerce); and Sir William Larke (National Federation of Iron and Steel Manufacturers), who was a very good friend to the London Branch, and whose name he coupled with the toast.

SIR WILLIAM LARKE, K.B.E., responding, emphasised that the kindred associations were friends bound by the link of common interest, and, now that we had learned the value of exchanging information, we were learning in industry more than ever before that however much we might think we had discovered that was original we could never repay the debt in the present that we owed to the past. In exchanging such information as we had to exchange, we must remember that we were only bringing the experience of each to the notice of all, and the experience of all to ourselves. In fact, to paraphrase an old song and toast, "The more we are together, the wealthier, the more important and the happier we shall be."

The Visitors.

COMMANDER WITHERS, C.I.E., R.I.M., proposed the toast of "The Visitors," to whom he extended a hearty welcome. Among those he mentioned specially were Mr. Henderson, Mr. Lea (of Singapore), Mr. Martin (of South Africa), M. Montfort (of France), Mr. Crittall, Mr. Booth, Mr. Perkins, Mr. Goodwin, Mr. Cameron and Mr. J. G. Pearce.

MR. V. G. CRITTALL, in the course of an amusing response, apologised for having in the past used foundrymen in a way which was perhaps hardly fair. Foundrymen, he said, had often been a convenient excuse, not only in his own business, but in many others which relied upon the foundry for their raw material. He congratulated the Institute upon the cleanliness of its aims and objects and upon its obviously genuine desire to improve the industry. He only wished that in many other businesses there existed mutual improvement associations such as this, shorn entirely of the other less altruistic considerations which were so often the only considerations which bonded the members of a trade.

Importance of Research.

MR. J. G. PEARCE (Director of the British Cast Iron Research Association) also responded, and referred to a somewhat trenchant remark made by Lord Aberconway in his new book dealing with the basic trades, to the effect that the only prophylactic against unemployment was research. As Director of the British Cast Iron Research Association, said Mr. Pearce, he too had found very often that industry was regarded as a sort of horse, and research as a kind of cart, to be dragged at the tail of the horse, a cart which could not move until the horse was going very strongly. The day might come, he hoped, when we might see the virtue of putting the cart before the horse. The Research Association wanted membership, and it wanted criticism and help, but it did not want criticism of the kind of which the burglar had complained when, having been charged and asked if he had anything to say in his defence, he had replied that the only thing that really offended him was "being identified by a bloke what had got 'is 'ead under the bed-clothes all the time." (Laughter.) There was a moral in that story, but he would not press it. (Renewed laughter.)

The "Sand Rat."

The final toast was that of "The Sand Rat," which was proposed, as has been the custom for the last year or two, by MR. H. G. SOMMERFIELD (Branch Hon. Secretary and Treasurer). It was the time-honoured custom of the London Branch, he said, to drink the health of the men to whom they referred as "the Sand Rats," and they spoke of those men as "Sand Rats" in all sincerity and affection. Those men contributed their quota to the general well-being as much as did the men of science, and, therefore, the members of the London Branch gladly raised their glasses to them. He believed that the great *esprit de corps* which was so evident in the Institute of British Foundrymen was due to the fact that it embraced the moulder as well as the eminent scientist, and the men who grovelled in the sand by day, and often by night, in order to produce to the engineer castings worthy of the name of foundrymen, must not be forgotten.

An excellent musical programme was rendered during the evening, and the proceedings terminated with the singing of the National Anthem and "Auld Lang Syne."

Seven Lean Years.

BY A SCRAP DEALER.

During the war years manufacturers of non-ferrous materials occupied on Government contracts were compelled to utilise immense quantities of scrap in the production of cartridge metal, powder case sheets, and copper shell bands, and the taste for secondary metals thus acquired has persisted down to the present time. In the foundries casters grew accustomed to heats comprising a large proportion of scrap material, and in the office selling prices were calculated accordingly. In short, scrap came into its own and showed what it could do.

The boom years following the Armistice brought a flood of scrap of the very highest possible quality on to the market, and first-class material changed hands at what now appear ridiculously low prices. Shell cases without stain or blemish vanished into the melting pot to reappear as brass sheets or strip, and shell bands of high purity copper were run down in hundreds of tons for the manufacture of India sheets. Those were halcyon days, for business was good and profits were ample, but everything has an end, and the time came—prolonged, it is true, by the slump at the end of 1920—when "war surplus" began to show unmistakable signs of petering out.

Slowly but surely the margin on brass scrap narrowed, until last year saw shell cases sold at prices over mixture value, and copper scrap was purchased at a premium over best select ingots. Absurd if you like, but it serves to show how strong is force of habit in our industrial life. The truth is, of course, that the war years set scrap on a pinnacle of fame from which it has never been displaced, and it is now as much a commodity "on its own" as pig-iron or spelter.

And so we come to the present time, when in the world of scrap a vivid contrast is presented between conditions in the ferrous and non-ferrous trades, for whereas in the former the accumulations which were amassed during the weary months of the coal strike are not greatly diminished, the state of affairs in the latter resembles nothing so much as famine. Germany "lifted" large quantities of copper and brass scrap from our market in the second half of last year, and many of the usual sources of supply were closed owing to the shortage of fuel, with the result that dealers are hard put to it to-day to find suitable material for their customers.

There is, however, another aspect of the case which must not be overlooked. It has already been suggested that during the years of plenty manufacturers came to recognise that the "best was always good enough," and having based their foundry practice on that very sound maxim, they have stubbornly resisted all attempts by dealers to pass on anything below their standard of excellence. As long as there was enough and to spare for all concerned, such stipulation mattered little, but the changed conditions are now showing up the weak spots in the situation.

A visit to any of the great metal sheds at large railway stations will illustrate the present position in miniature, for there the observant visitor will notice heaps of derelict scrap which nobody appears to want, and which, from its forlorn and neglected appearance, seems to have lain there for years. As a matter of fact, it probably has. The cream has been skimmed off the milk for the past few years, and we are now reaching the stage when apparently manufacturers must make up their minds to accept a rather lower grade of scrap than that to which they have been accustomed in the past.

At a rough estimate copper comes on to the market in the form of scrap ten years after going into use as finished material, and during the later periods of the war very little metal was worked up into commercial articles. It is true that the "condemned stores" offered by the G.P.O. twice a year provide a fairly large tonnage of wire for melting, but much of this material is far from high-class owing to oxidation, etc., and many buyers will not consider the bronze wire at any price.

The railway companies, another fruitful source of supply of copper scrap in the past, are now compelled to study economy in every possible way, and material which might have been scrapped in pre-war days now hangs on a year or two longer. Moreover, steel tubes have replaced copper and brass in many engineering enterprises, as well as in locomotives, and the upshot is less non-ferrous scrap for the trade. Turning to the shipbuilding industry we find that the stagnation of the past few years is only now giving way to some semblance of activity, but even so the number of ships in the shipbreakers' hands is relatively few.

Germany, happy in the possession of several millions of English money paid to her for coal shipped to this country during the past nine months, is busy replenishing the stock of non-ferrous materials of which the war robbed her, and she is apparently able and willing to pay prices in excess of those which the British manufacturer, hampered by heavy taxation and competition from abroad, can afford.

All these factors are now bearing on the situation in scrap metal, and recent price movements have reflected its growing scarcity. Buyers, with the recollection of the palmy days following the war, still expect first-class material at an ample margin under mixture values, but it is safe to say that they will be disappointed, for there is now no floating surplus of secondary metals, and the years ahead hold no promise of any relief in this direction.

It has been suggested that copper "returns" every ten years, but this is, of course, only true of metal that remains above ground, such as telephone wire, locomotive fireboxes, tubes, etc. By far the largest tonnage of the red metal goes in the manufacture of cable, which lies buried for a great many years, and the increasing spread of electrical installations and power schemes will make this proportion greater as the years go on. This material may be written off as lost as far as the scrap trade is concerned, and the tendency in other directions, *e.g.*, condenser tubes and steam pipes, is to produce non-corrosive units which will give a maximum life and keep the material off the scrap dump as long as possible.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Cast-Iron Pipe Makers.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The announcement was made in several of the newspapers recently that an International "ring" of cast-iron pipe makers had been brought into operation, covering America, England, France and Germany, and the name of this company was quoted as the British firm in that "ring."

The Stanton Company are the largest producers of cast-iron pipes in Europe, made both centrifugally and otherwise, and we desire emphatically to deny any suggestion of any financial arrangement in regard to capital, or in regard to selling prices, with producers either at home or abroad.

We should be glad if you would give wide publicity to this statement, bearing mind the incorrect information which has been circulated.—Yours, etc.,

for THE STANTON IRONWORKS COMPANY, LIMITED.
E. J. FOX,
Managing Director.

December 12, 1927.

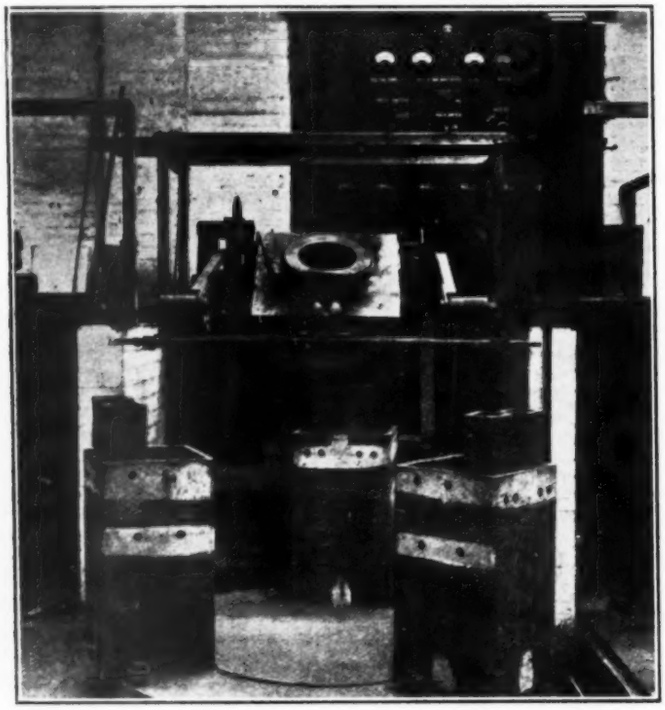
PNEULEC, LIMITED, of Mafeking Road, Smethwick, Birmingham, are demonstrating the merits of the Pneulec Royer sand-mixing machine at 290, Stockport Road, Ardwick, Manchester, from January 9 to 23, 1928.

THE Universal System of Machine Moulding and Machinery, Limited, have changed their address from 97, Queen Victoria Street, to 13 to 15, Wilson Street, London, E.C.2. The 'phone number is Clerkenwell 1276, and the telegraphic address "Machimould, Finsquare."

Demonstration of the Ajax-Northrup High-Frequency Electric Furnace.

On the invitation of Messrs. Edgar Allen & Company, Limited, our representative visited the Imperial Steel Works, Sheffield, on Tuesday week to witness a demonstration of the Ajax-Northrup furnace, the first of its type to be laid down for the manufacture of crucible tool steel.

The most recent development of the high-frequency melting is the motor-generator type of Ajax-Northrup furnace, built by the Electric Furnace Company, Limited, London. A demonstration furnace of this type was erected by this firm, at Bilston, Staffs., and was used for melting steel, brass, copper, pure nickel, nickel silver, aluminium, etc. The demonstrations were watched by Messrs. Edgar Allen & Company, who quickly recognised the advantages of the furnace for melting high-grade steel, the outcome being the installation at their Imperial Steel Works of the first plant in the world for making tool steel in a high-frequency furnace on a commercial scale. It is of the crucible type, of 400 lbs. capacity, in which the metal is melted by high-frequency current, conducted to a water-cooled coil surrounding the crucible. By this means all the advantages of the old crucible process are retained, while no deleterious gases are introduced and the cost is greatly reduced. The mixing is also exceptionally good, owing to the violent stirring caused by the electric currents.



High-Frequency Electric Furnace for the Manufacture of High-Grade Tool Steel.

Current for operating the furnace is taken from the sub-station of the Sheffield Corporation at 350 volts, 3-phase, to the auto-transformer in the power house at the rear of the furnace, the starter being of the star-delta type with full automatic features. The generator set consists of a squirrel-cage induction motor of 270 h.p., running at 3,000 r.p.m., direct coupled to a self-exciting alternator of 1,200 volts, 2,200 cycles. The electrical portion of the plant was supplied by the English Electric Company, Limited.

For the purpose of the demonstration a melt was made of a charge of 400 lbs. of 1.30 razor steel, the metal being poured in approximately an hour from the time of charging. In the actual operation of the furnace no trouble whatever has been experienced. The present energy consumption is approximately 850 units per ton of saleable ingots: this figure cannot, however, be regarded as representative, seeing that for the time being the furnace is only worked intermittently; were the furnace worked to its full capacity output, the total cost of melting would be approximately the same as that of a small Héroult arc furnace, the extra cost of crucibles being about equal to that of electrodes. The life of the crucible is of course a most important factor in the economical operation of the plant (Morgan plumbago crucibles are employed). In the initial stage the life of these was very short: at the present time they are giving from 9 to 12 heats, and there is every reason to believe that experience will enable still further economies to be made in this direction.

From the demonstration and the data available, it would seem evident that the Ajax-Northrup high-frequency furnace is as commercial as it is practical, and bids fair to have a very far-reaching effect on the crucible-steel industry as a whole, and Messrs. Edgar Allen & Company deserve congratulation upon their early appreciation and pioneer enterprise.

Alloys with High Nickel and Chrome Contents.

M. Chevenard (professor at the National High School of Mines at St. Etienne and head of the Scientific Research Department of the Société Anonyme de Commentry-Fourchambault et Decazeville) in the course of a lecture recently delivered during the "Nickel Week"* at the Conservatoire National des Arts et Métiers, in Paris, on alloys with high nickel and chrome contents, pointed out the great variety of alloys which could be obtained by the additions of chrome, iron, tungsten, etc., to nickel, and the fruitfulness of the application of scientific methods to industrial research. After recounting the various properties of nickel, M. Chevenard described the modifications of these properties by means of a chrome addition. The action of chrome, the nature of which—he said—is both physico-chemical and purifying, was represented quantitatively by numerous diagrams relating to the fusibility, magnetic transformation, density, capability of expansion, resistance, thermo-electric power, specific heat, thermo-elasticity, viscosity, etc., of these alloys.

The lecturer then gave a similar explanation in regard to ferro-nickels, to which chrome is added. He showed how the action of the chrome, which weakens in some cases beyond a certain content, may be strengthened by other additions.

In a second part of his lecture the author described, in regard to some of these problems, the solution realised at the Imphy Steel Works. "Elinvar," which was composed in collaboration with M. Guillaume, possesses a modulus of elasticity independent of the temperature between −50 deg. and +100 deg. C. The "Pyros" alloy, which is heat-resisting, not easily oxidisable, and without anomaly, is employed in the construction of dilatometers, which, according to M. Guillet, have transformed the working methods of metallurgical laboratories.

M. Chevenard also discussed thermo-electric couples, alloys for electric resistances, alloys resisting fire and corrosion, etc. By way of example he described the problem of glass-ware moulds, which is very complex owing to the multitude of factors involved: resistance to reticular fissuration, which in its turn was a function of dilatability that is deformation capacity, the thermal conductibility of the metal, the method of working, etc. Another factor involved is a high degree of hardness when hot, resistance to oxidation, suitability for obtaining fineness of structure when forged, etc.

The "Moulimphy" alloy, produced with the collaboration of Messrs. Portevin and Baurot, made it possible to manufacture over 2,000,000 bottles of very good appearance with the same mould at the Montenon glass works, whereas the special kinds of cast iron habitually used did not permit of more than 50,000 bottles being made.

The synthetic-ammonia process of M. Georges Claude involves the use of metals retaining good mechanical properties at high temperatures, while at the same time they have to resist the action of chemicals. While the tubes of special steel used at first lasted only a few hours, tubes of B.T.G. alloy, prepared at the Imphy Steel Works, which are at present in service, have been in use for more than 15,000 and even as many as 20,000 hours without there being anything to indicate that they will soon be worn out.

M. Chevenard then described the fissuring corrosion of ferro-nickels in steam, a phenomenon physico-chemical and at the same time chemical in its nature. By a liberal addition of chrome such corrosion can be obviated. The alloys known under the name of A.T.V. are absolutely immune from fissuring corrosion.

(*a*) *Steam-turbine blades:* These blades are exposed to superficial corrosion, to erosion by small drops of water, and to considerable mechanical stresses. The A.T.V. alloys resist all these remarkably well. These alloys, used under the most difficult conditions for turbines with sea-water or brackish water in the condensers, or for powerful units (50,000 kw.) at very high superheating (400 to 425 deg. C.), never showed any trace of corrosion, whereas under the same conditions steels with 5 per cent. nickel, 13 per cent. chrome, etc., were but short-lived. The A.T.V. alloys also resist erosion better, probably because of the well-known toughness of ferro-nickels containing chrome.

(*b*) *Internal-Combustion Engine Valves:* These work at high temperatures and are exposed to the chemical action of the exhaust gases. It was therefore natural to have recourse to ferro-nickels containing chrome hardened by suitable additions. These alloys, compared even with silico-chrome or chrome-tungsten steels, which are frequently recommended, have the advantage of retaining longer their initial properties under the influence of prolonged heating.

* October 16 to 27.

The death is announced of Mr. E. Whitfield, who was chairman of McFarlane and Whitfield, rivet manufacturers, Dunston.

Some Developments in Engineering Bronze Founding.

A Paper on this subject was read by Mr. F. W. Rowe, B.Sc., at the second meeting of the session of the Scottish Branch of the Institute of British Foundrymen, held in the Royal Technical College, Glasgow. The meeting was a joint one with the local branch of the Institute of Metals.

Mr. Rowe said that though the developments and improvements which had taken place in engineering bronze-founding in recent years had not been so rapid as those which had taken place in the light alloy founding industry, nevertheless, the engineering bronze-founding industry had not stood still. The stress of competition during the last few years had made it imperative that more rapid and cheaper methods of production be adopted. The high cost of bronze castings had also resulted in the weight being cut to the very minimum, and the stresses which bronze castings were now subjected to were such that only first-quality material was able to withstand them.

One of the most important points in this branch of engineering was the method of melting the metals and alloys for casting. Good melting practice with the use of suitable raw materials was half the battle, and all the time and trouble expended on this part of the process was amply repaid both as regards costs and the quality of the work produced.

Probably 70 per cent. of the bronze melted in this country was melted in coke-fired pit furnaces. One of the main factors in the case of a crucible pit fire was the fuel consumption. Figures varied in this direction, but even the best figures for fuel consumption showed a very low thermal efficiency. He had taken figures in various foundries, and the best he had been able to get, working with Admiralty gunmetal or a similar alloy, was about 38 lbs. of coke to 100 lbs. of metal. This represents 7 per cent. efficiency. Of course, these figures were very poor, but startling as they might seem, they were better than the figures obtained in steel melting in a crucible pit fire where the efficiency was about 4 per cent.

The next most important item was, of course, the cost of the crucibles themselves. Here again figures varied as to the average life of a crucible, but with small pots 50 heats on an average was a very good life. In the case of larger pots it was very seldom that they were able to maintain so high an average. The figure generally fell to about 35 or 40 heats.

It would be seen from Table I that the crucible cost per ton represented about 20 per cent. of the total melting cost, and that the fuel cost represented about 30 per cent. of that figure. Naturally, attention had been directed in recent years

TABLE I.—*Cost of Operating a Crucible Pit Fire Furnace.*

Alloy, 12 per cent. Tin Bronze.

Total operating time	9½ hrs.
Charge weight	160 lbs.
Melting time	1½ hrs.
Casting temperature	1,200-1,250 deg. C.
Weight melted per day ...	960 lbs. (6 heats).
Fuel cost per ton (38 per cent.)	17s. 6d.
Labour per ton...	18s. 6d.
Crucible cost per ton	10s. 6d.
Repairs per ton...	2s. 0d.
Depreciation and interest ...	1s. 3d.
Total cost	49s. 9d. per ton.

both to improving thermal efficiency and cutting out the cost of crucibles. Most of the furnaces recently installed were of the non-crucible type, and showed a high thermal efficiency compared with the old crucible furnaces.

The next most popular method of melting was to use the tilting type of crucible furnace, such as the M.R.V. or Morgan furnace. In practice this type did not show a great economy over the ordinary pit fire, the great advantage of the tilting crucible furnace being that it could deal with a greater amount of metal at the one time. With the tilting type 600 to 800 lbs. was quite a common capacity. In discussing all these cost figures he should point out that it was usually possible, by "sitting over" a furnace and keeping it in really first-class condition, to reduce these costs. But the figures he had given them were those obtained over a six months' period, and he did not think they could be very much improved upon.

Reverberatory Furnaces Reduce Melting Costs.

At Huddersfield they had installed a battery of tilting reverberatory furnaces for the major portion of their production. The battery for the centrifugal bronze foundry consisted of three half-ton units and a one-ton unit. They found that with this type they very materially reduced their melting costs. They are illustrated in Fig. 1.

Table II showed a cost sheet taken out for a six months' period with a half-ton reverberatory furnace. The fuel cost per ton had been cut down

TABLE II.—*Cost of Operating a ½-ton Reverberatory Furnace.*

Alloy, 12 per cent. Tin Bronze.

Total operating time	9½ hrs.
Charge weight	1,120 lbs.
Melting time	1 hr. 15 min.
Casting temperature	1,225-1,275 deg. C.
Weight melted per day ...	5,600 lbs. (5 heats).
Fuel cost per ton	12s. 0d.
Labour per ton...	11s. 0d.
Current and repairs per ton...	3s. 0d.
Depreciation and interest per ton	3s. 0d.
Total cost	29s. 0d. per ton.

to 12s. against 17s. 6d. in the case of the pit-fire type. With the reverberatory furnace, of course, more money had to be spent on the lining, but the net result, after allowing for that extra expenditure, was that they had been able to reduce their melting cost from about 50s. to about 29s. per ton. The half-ton furnaces were giving about five heats per day in a 9½ hours' day, but that was not the maximum capacity of the furnace. If they were able to take the whole of the metal immediately it was ready for pouring they could get another heat. The first heat with the half-ton furnace took from 1½ to 2 hours. After that they could get another heat about every 75 minutes, depending on the size of the metal or the scrap. The one-ton furnace was chiefly used for remelting the turnings and borings from the machine shop into ingots.

The main trouble with that type of furnace had been to find satisfactory lining materials, and methods of making the lining stand up to wear and tear, particularly in the fire-box. The furnace developed a very high temperature in the fire-box—about 1,650 to 1,700 deg. C.—and they had considerable difficulty in finding a refractory that would stand up to that temperature. They now lined the fire-box with sillimanite bricks, arranging the direction of the brickwork to the best advantage. One of the main factors with this furnace was to keep the lining really clean. If the furnace was dirty, with slag on the sides and the hearth, poor results were obtained. They made a special effort to keep the lining in such a condition that they could see every brick in the furnace at the end of the day. A certain amount of extra coke was used in that way, but that was taken into account in the figures given for fuel cost per ton. They spent 20 to 30 mins. every night getting the furnace heated up for this purpose, and in addition to that, every two or three weeks they brought the furnace up to the requisite heat, removed the tapping plate, and scraped it thoroughly to expose every brick in the furnace.

One of the most serious competitors in the near future would be the electric furnace. He was afraid that in this country they were apt to dismiss the question of electric heating too lightly. When one mentioned electric heating and pointed to the wonderful strides made in this direction in the United States, the most frequent remark made was that it was too dear in this country, and that only the low price of power in America enabled electric furnaces to be used. He thought, however, that these objections were not strictly accurate. The average price paid for power for industrial heating in the States was not much lower, if any lower, than the price which would be charged by any progressive electrical undertaking in this country. They should remember that in America they had vast supplies of oil fuel, which could be bought at a much cheaper price than they could get it in this country. In Britain to-day oil fuel cost about 90s. per ton; in the States it cost about 50s. per ton. It would seem reasonable to suppose that oil fuel would be used more than electric heat if it was as good. Pretty nearly any electrical undertaking in this country would charge less than a penny per unit for current for industrial heat, yet in America many people were paying more than that.

The main item in the installation of an electric bronze melting plant was the high capital expenditure involved, and, of course, the subsequent high overhead charge in depreciation. In the United States most of the foundries were equipped with Detroit rocking electric furnaces, shown in Fig. 2.

The chief disadvantage of this type was that it worked with single phase. It was very extensively used in the States, where between 500 and 600 of them were in operation at the present time. Table IV showed the figures for the working of a larger type of Detroit furnace (750 lbs.).

TABLE IV.—*Cost of Operating a 750-lbs. Detroit Furnace.*

Alloy, 8 per cent. Lead Gunmetal.

Total operating time per day	9½ hrs.
Charge weight	750 lbs.
Melting time	55 min.
Casting temperature	1,200 deg. C.
Weight melted per day ...	3 tons (8 heats).
Power cost per ton	24s. 0d. at 1d. per unit
Labour per ton...	4s. 0d.
Electrode and lining cost per ton and maintenance ...	6s. 0d.
Interest at 6 per cent. and depreciation at 17½ per cent	18s. 3d. per ton.
Total cost	52s. 3d. per ton.

The figures given were obtained from a large works in the States. If it were not for the heavy depreciation charges, it would certainly form a very economical proposition. Eight heats of 750 lbs. each at a penny per unit—rather more than was being paid—was 24s. per ton, as against 17s. 6d. for a crucible pit-fire furnace. These figures were taken over a long period. The labour

TABLE III.—*Cost of Operating Induced Draught Crucible Furnaces.*

Alloy, 12 per cent. Tin Bronze.

Total operating time	9 hrs.
Charge weight	400 lbs.
Melting time	1¾ hrs.
Casting temperature	1,200-1,250 deg. C.
Weight melted per day ...	2,000 lbs. (5 heats).
Fuel cost per ton (35 per cent.)	16s. 0d.
Labour per ton...	18s. 0d.
Crucible cost per ton	12s. 0d.
Current and repairs per ton...	2s. 6d.
Depreciation and interest per ton	2s. 0d.
Total cost	50s. 6d. per ton.

required for an electric furnace was very little, one man being able to work a 750-lb. furnace without any trouble. All he had to do was to put the metal in, switch on the current, and keep it properly adjusted. The lining cost was heavy, but against that they had no crucibles to pay for. Electric plant was certainly the cleanest they could wish. Apart from that, there were certain other advantages which could not be put into figures. The working conditions were certainly much better, for there were no ashes and no gaseous fumes. Regarding the heavy depreciation figure, of course, the makers of the furnace would insist that the figure shown was much too high, and that their furnaces would last longer than seven years; but in dealing with this plant one was always faced with the fact that fairly radical

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improvements would probably be made in the next few years, rendering existing plant obsolete.

Melting practice had a considerable influence on the quality of the metal produced in bronze founding. Probably the most important factor was the speed with which melting was conducted. Rapid melting was the main factor, and the furnace which would bring down the heat in quick time should be regarded with favour. During any commercial melting process a certain amount of oxidation was bound to take place, no matter what kind of fuel was used. He had never yet seen a melting furnace which had anything like a reducing or neutral atmosphere. There was always an oxide formation, and it was very difficult to get a truly reducing atmosphere. The longer the metal was exposed to the furnace atmosphere the greater the amount of oxidation. It was, of course, possible to effect some improvement by the use of de-oxidants, but it was better to avoid oxidation.

There was also the question of gas absorption in a bronze. It was obvious to presume that the metal which was longest in contact with the fuel would be liable to absorb most gas. There was a fallacy that the metal in the interior of a crucible was protected from gaseous absorption. He did not think that any material amount of protection against gaseous absorption was given by the ordinary crucible. The effects of oxidation and gas absorption were somewhat difficult to differentiate, and much research work was needed before it could be dogmatically stated which of the many troubles in bronze founding were due to liberation and absorption of gas. If one attempted bronze founding with dirty raw materials and with slow melting, coupled with exposure to the atmosphere, one was certain to encounter trouble. They had arrived at a stage when they could state with certainty that a high proportion of ingot copper in any charge would result in troubles due to gas liberation or gas absorption. This was now generally attributed to the practice of copper founders in leaving a fair proportion of oxide in the copper. This, of course, was done to enable them to cast a clean-looking ingot.

In alloys with a high percentage of tin, particularly if phosphorus was present, inverse segregation or tin sweat was a very valuable guide to the quality of the metal being poured. It could be safely said that with the ordinary alloys, where casting temperature and conditions were correct, no tin sweat should be seen on the surface, and it should be the object of every bronze founder to see that his metal conditions were such that no tin sweat appeared. He did not insist that because a runner or riser had tin compound beads on it it was scrap, but it would be found that the general properties of the metal would not be the best of which the alloy was capable. The risers and runners should have a hollow surface. They should not be convex.

Mr. Rowe showed a fracture of a half-bearing sand casting. The fracture was obtained by squeezing the half bearing in a vice. Some might insist that such a fracture was entirely due to gas absorption. He could not agree, and he certainly thought that oxide inclusions had a serious influence.

Micro sections of several fractures were shown. In the first, films of oxide, which caused an intergranular fracture, could clearly be seen. The fracture would take place quite easily along these films. The second showed the same sample lightly etched. It could be seen where the holes were compound the high tin had disappeared, and the thin films running round each crystal boundary. The third showed more clearly some oxide inclusions in another sample. It showed slag inclusion, which resulted in a fracture at very low stresses.

To avoid such troubles, several standard rules should be observed. Whether one was melting in a pit-fire crucible or in a non-crucible furnace, one should make sure that the container was very well heated before charging the metal, to ensure rapid melting. This would not give low fuel consumption, but it was preferable in the long run. In the case of Admiralty gunmetal the temperature should be 1,300 to 1,400 deg. C. before any metal was added. It was the practice in his works to get the pot up to a white heat, to ensure rapid melting on the first heat. They also avoided as far as possible high percentages of a new metal. They preferred 25 to 30 per cent., unless they were using electrolytic copper. They also avoided as far as possible light scrap, and if they had any dirty scrap which had to be worked up, they always sand-blasted it, or melted it into ingots and refined it before using it in the actual charges for casting. They had tried a great many fluxes from time to time, but had found them more trouble than they were worth. They relied on a good covering of charcoal to prevent any surface oxidation when melting.

Apart from these questions of oxide and gas inclusions there were the questions of running conditions, casting temperature, and runners and risers. If they required castings of high strength and good physical properties generally, correct casting temperature was important, but it could not be considered by itself. It was not possible to give a definite casting temperature for any particular alloy, because a great deal depended on the size and shape of the casting, and the conditions under which the metal was being run. What really mattered, and what was rather difficult, was to find out at exactly what temperature the mould was filled. The ideal to achieve when casting evenly distributed sections was that the mould should be filled with molten metal at the same temperature. That was rather difficult; but a great many scrapped castings could be attributed to the mistake of having the metal in the mould much hotter at one point than another. In this matter they had a very easy guide in the grain size of the metal.

The grain size of every alloy under a definite standard set of conditions varied, of course, with the casting temperature. The higher the casting temperature, the longer the period of solidification, and the larger the grain size. If the casting were machined, one could nearly always tell the size of the grain without having to destroy the casting for that purpose. A great many troubles were due, for instance, to the metal being at the correct temperature when it entered the runner, but being too cold somewhere else. When casting an uneven section it was still more difficult to fill each part of the mould with metal of the correct temperature. It was necessary to see that the period of solidification in each section was such as would give a metal of good properties. The lighter sections of the mould should be filled with metal of a higher temperature than the heavier sections.

The grain size of any alloy was intimately connected with the strength of that alloy, and a great deal of useful work could be done by controlling the grain size, just as it was controlled in the heat treatment of steel.

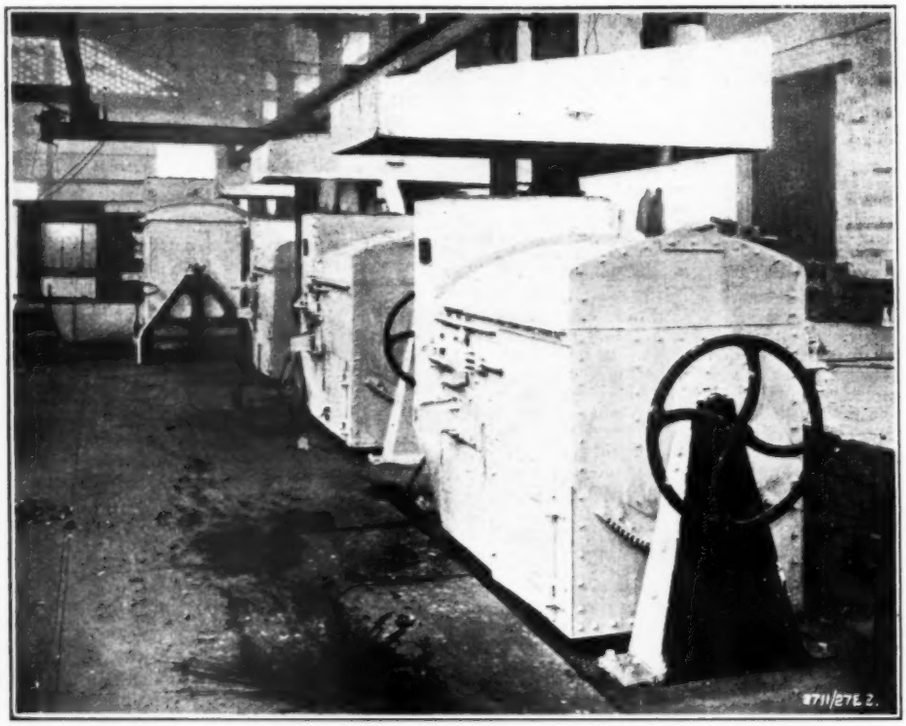


Fig. 1.—A Battery of Reverberatory Furnaces installed at the Works of Messrs. David Brown & Sons, Limited, Huddersfield.

Centrifugal Casting of Bronze.

Most of this work done by his firm was bronze or phosphor bronze for wearing surfaces, and he supposed that most of them were familiar with the general constitution of such alloys. The composition of such metals was fairly well standard. They consisted of plain tin-bronze, with 11 to 12 per cent. of tin, and with or without a certain proportion of phosphorus. The idea in using phosphor bronze was to get a metal with mixed crystals—crystals of different hardness. In such metal the tin compound was the hardest, and its crystals were embedded in a soft alloy matrix. The theory was that these hard particles took the load and resisted the wear, while the soft metal bedded down and allowed the bronze to adjust itself to any inequalities of the surface against which it was working. Whether that theory was true in every detail he was not prepared to say, but certainly the friction of bronze, working against steel, was considerably lower than any other alloy which had been found, except white metal, which was too soft.

One or two impurities had to be avoided. Zinc should sometimes be kept out of the mixture. The effect of zinc was to increase the hardness of the softer portion, and thus lessen the difference between the hard and soft portions. Lead was a valuable addition if one could permit the low yield point which resulted, and the lower general physical properties. The lead formed soft pockets and softened the matrix, making a greater difference in hardness between the general body and the hard spots.

The effect of phosphor on phosphor-bronze was not quite clear. At the Huddersfield works they had recently favoured a very much lower content of phosphorus than was commonly use. It was thought formerly that the hard particles of phos-

phide of copper were in general responsible for the good frictional qualities of phosphor-bronze, but recent research had shown that the hard particles of phosphide of copper were by no means as hard as those of tin compound, and that phosphorus had a serious effect on the shock strength of such alloys. They preferred tin to phosphorus as a hardener. It was also slightly better as regards wearing.

Phosphor-bronze had quite good physical properties, having a tensile strength of 18½ tons per sq. in., and an elongation of 30 per cent. Most of his firm's work was automobile worm wheel blanks. These were not easy bronze castings to make, particularly in the centre. The roots of the teeth represented the very centre of the casting, and therefore, that portion of the casting which was likely to be unsound. In the old days they were faced with a considerable proportion of scrap, although some of the defects were not very apparent. They would readily appreciate the fact that the very heart of the casting was the most likely part to be faulty in the direction of porosity, and to overcome this difficulty of slight porosity they had cast these blanks with a chill round the periphery.

This method of casting improved matters considerably. It was certainly a decided improvement over a sand casting. Chilling the outside, however, had one or two disadvantages. It was liable to cause the outside portion of the wheel blank to be sound at the expense of the inner portion, and while a small amount of porosity and unsoundness was not a very serious feature, it prevented them from lightening the design. Another disadvantage of chill casting was that the differential rate of cooling resulted in a structure which was not the best of which the alloy was capable.

Naturally, from chill casting with a ring on the periphery they progressed to casting these wheel blanks in a complete steel mould, except that it had a sand core. While this improved the properties of the alloy as regards structure and density, and general soundness, it proved hardly a commercial proposition. The chief trouble in attempting to die-cast phosphor-bronze was the difficulty of providing sufficient feed for the rapidly contracting metal, and they found that the temperature at which the metal had to be poured, and the temperature to which the moulds had to be heated, was such that they lost some of the advantages of chill casting, in that the grain size was larger than generally occurred in ordinary chill casting.

From that they proceeded to centrifugal casting. There were two considerable advantages in centrifugal casting. First, the smaller grain size. This was apparently due to the fact that the metal was kept in a state of agitation during the whole period of solidification. Some people were inclined to attribute the good qualities of centrifugal casting to the fact that the casting was made in a steel mould; but the grain size was very different from that of an ordinary die casting. That, he believed, was due to the constant stirring up of the metal while it was cooling. The second advantage of centrifugal casting was that the feeding was automatic. They were forcing metal in to fill up the cavities during the whole period of solidification. The actual pressure developed in the process his firm was using was about 50 lbs. per sq. in. By this process they did away with the troubles of liquid contraction.

New Developments.

One of the most important items in bronze founding to-day was the present high price of tin, and the price was likely to remain high for some little time. A good many efforts had been made in recent years to find a substitute for tin, and one or two metals or alloys gave great promise of success. Americans, with their great fondness for nickel, were using a large amount of that metal in place of tin for most of their quantity production work in bronze. The standard phosphor-bronze such as was used for chill-cast bronze-bearings was now being made in the United States with between 2 and 3 per cent. of nickel, the tin content being cut down by 1 or 1½ per cent. He had recently received results of long-service wear tests with this bronze having the nickel content, and it certainly seemed from these results that the nickel had a definite advantage. The addition of nickel to bronze or phosphor-bronze raised the tensile strength and hardness. The nickel also appeared to give a higher fatigue strength in service.

Very good results had recently been obtained from some of the aluminium-nickel-copper alloys. These alloys had 7 per cent. of aluminium, and 5 per cent. of nickel, and the rest was copper, with a few small differences. These alloys had been investigated in recent years, but they did not seem to have been adopted commercially except in one or two cases. Of course, aluminium bronze generally formed a strong temptation, and gave on test very high physical properties; but an ordinary aluminium bronze was very difficult to cast. It had been found that with a lower aluminium content and a practicable amount of nickel—4 to 5 per cent.—the difficulties in founding were very little, if any, greater than with ordinary bronze, particularly if silicon and manganese were added to the alloy. An alloy now with 0.4 per cent. of silicon, in addition to 7 per cent. of aluminium and 5 per cent. of nickel, was regularly giving tests of 35 to 40 tons, and had none of the disadvantages of manganese bronze as regards being easily corroded. It gave good working qualities, though not as good as phosphor-bronze, and their efforts were being directed to improving the bearing qualities of such alloys.

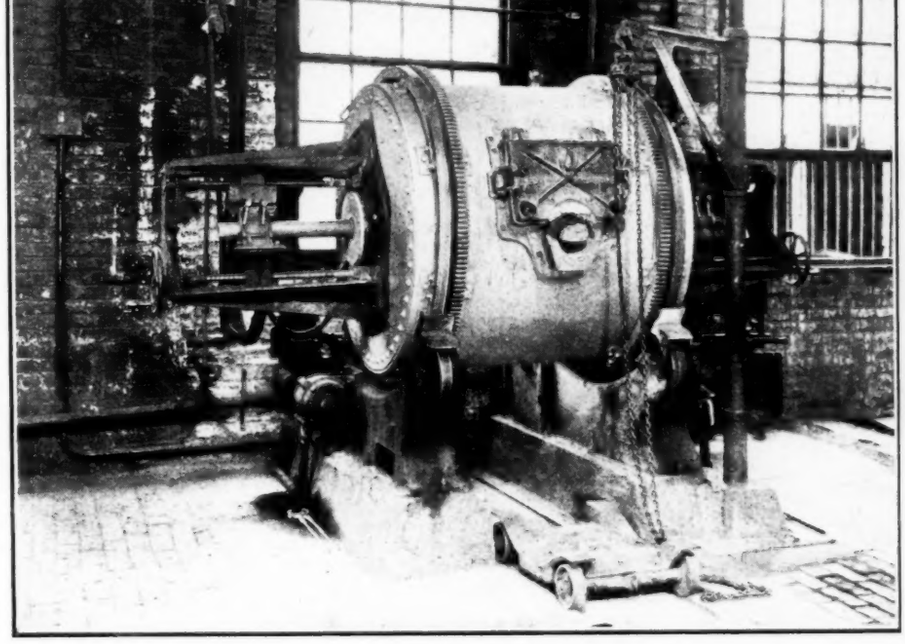


FIG. 2.—THE DETROIT ROCKING FURNACE.

DISCUSSION.

MR. LONGDEN said that Mr. Rowe had shown that the cost of the ordinary pit fire furnace was remarkably low, and after all that was the criterion. While one could see the value of the electric furnace, one had to have some regard to the question of cost.

MR. DICKIE raised the question of the comparison of costs between the ordinary pit fire and the reverberatory furnaces—49s. to 29s.—which was £1 per ton of difference. One per cent. of difference on the melt would just save that. How did these figures come out?

MR. ROWE said that that was a point they were very much afraid of when they put in reverberatory furnaces for bronze melting, and they had taken very careful tests. The melting loss with a reverberatory furnace was certainly no higher than with a crucible furnace. In melting phosphor-bronze cuttings into ingots they had a melting loss of 0.8 per cent., and 0.3 per cent. when melting ingots for casting. That figure was, of course, the total metal loss, and was taken from the total stock returns to the store for each battery of furnaces. One could not melt a ton of metal and then weigh it. These figures were over long periods with two types of furnaces. There was no reason why the reverberatory furnace loss should be higher, because any oxidation that took place took place just the same in a crucible furnace. Provided one kept the oxidation loss low, there was no reason why the melting loss should be higher. In actual practice they had never found the difference in melting loss to be appreciable. That was their fear when they first installed these furnaces. They put in a big furnace first, and watched it carefully for twelve months before installing the others.

MR. F. HUDSON said that three points dealt with by Mr. Rowe had interested him very much. The first was the comparison of melting costs. In working out the cost of these various furnaces the actual melting cost was certainly of value, but in his opinion it was not the most important point in a foundry. The melting cost alone was no criterion to the actual foundry efficiency. For instance, cheap melting costs might result in an increased yield of defective castings, with a consequent reduction in general efficiency. With the Detroit electric furnace the melting cost was in fair comparison to the melting cost with the ordinary pit crucible fire, yet the melting loss in the electric furnace would be less than in ordinary crucible melting. Another important point in electric melting was that the metal, in his opinion, had better physical properties. Gas penetration was less, and the need to ingot the raw material before final remelting was unnecessary. All these factors were bound to have a definite financial value. He was very much interested in the Detroit electric furnace because at the present time his own firm, Messrs. Glenfield & Kennedy, Limited, were about to place an order for one of these units. They had considered a reverberatory furnace, but thought that with it gas penetration would be as bad as with the crucible furnace, or worse, and they wanted to overcome gas penetra-

tion as much as possible. This point should be considered.

The other point he wished to raise was in connection with grain size. Mr. Rowe had stressed the fact that it was most important to control the grain size in casting, and he would like further to stress that point. His firm's largest output was in manganese bronze, and they made a daily practice of taking a micro-section of every heat and rejecting the material if the grain size was over a certain limit.

Aluminium Bronze.

Regarding Mr. Rowe's later remarks about aluminium bronze, his firm had been doing tests with that material. The compositions were just the plain aluminium-copper-iron alloys, and considerable trouble was experienced in melting and casting. When these factors were eliminated the resulting alloy was remarkable in its properties. They could get a tensile strength of 35 tons per sq. in., with an elastic limit of 18 to 21 tons per sq. in., with 30 per cent. elongation on 2 in., and an Izod impact test of 40 ft. lbs. In manganese bronze although a tensile strength of 35 tons per sq. in. could readily be obtained, the elastic limit was only about 14 tons per sq. in., with an impact test of about 30 ft. lbs. Comparison of these test figures showed the remarkably improved torsional and fatigue resisting properties of aluminium bronze.

Mr. Rowe replied that in regard to the point raised about melting loss, when his firm were considering whether to put down reverberatory or electric furnaces, they had to take into consideration the fact that the greater part of their work was in tin bronze. The melting loss was never great with tin bronze. He did not think the Detroit furnace showed any advantage in this respect. As regards gas absorption, he did not think there would be as much difference between the electric and the reverberatory furnace as Mr. Hudson had suggested. He was interested to hear that there was a bronze foundry in this country that was putting in a Detroit electric furnace, as it was a type that was doing good service in the United States. The costs of melting were not lower than with the pitfire furnace, but against that they had the advantages of no ashes and better working conditions. With reference to the remarks made about aluminium bronze, the difficulties of founding were very great, but if the aluminium content was brought down to about 7 per cent. and nickel was added, most of these difficulties would be overcome, and they would get as good if not better physical properties. Work on this group would be well repaid.

Chills and Grain Size.

Dr. Hyman said he wished to associate himself with Mr. Rowe's remarks in connection with the production of sound castings in copper-tin alloys. It was better to have the melting conditions correct than to alter the chemical composition of the alloy. It was quite common among foundrymen when they were in difficulties to alter the composition rather than devote more attention to the melting conditions. With reference to the grain size on the castings shown, he would like Mr. Rowe to explain why in chilling the sand casting one got a coarser grain size next to the chill. One would expect a finer grain structure. This was also borne out in the castings which were made in an automobile worm wheel blank chill mould. These castings all showed a coarse grain size. Had Mr. Rowe tried the effect of heat treatment on any of these coarse grain structures? Mr. Rowe had made no remarks about the actual costing with the centrifugal process. Did that process increase the price of this casting in proportion to the better mechanical results obtained? He was interested in the use of nickel in these alloys. There was no doubt that nickel produced its good effect by causing a finer grain structure. It was possible by using some other high melting-point metals to get the same effect.

Mr. Rowe replied that the large grain size of the die casting was due to the fact that it was necessary to cast at a very much higher temperature than in the case of a centrifugal casting. This increased the period of solidification, so that the casting would feed itself. Similar remarks applied to castings with a chill on their periphery. It was necessary to cast at a higher temperature than in the case of a plain sand casting, which produced the large grain size. He was afraid that heat treatment of bronze was of very little value for bronzes that had to stand wear. Really there should be no tin compound present at all. It should all be in solution, and the effect of heat treatment was to take away the biggest part of the tin compound into solution, thus spoiling that hard and soft structure which was an essential for wearing qualities.

Mr. Arnott, moving a vote of thanks to Mr. Rowe, said he would like to commend his Paper to those members of their own Institute who were always asking for practical Papers. They always had difficulty in getting Papers from the people who were actually doing the job.

The Rough Copper Position.

By "Onlooker."

The stocks of rough copper in official warehouses at October 31 were returned at 13,436 tons, the lowest figure touched since 1922, and some 18,000 tons below the total at the end of last year, while stocks at December 31, 1925, were approximately four times as great as they are to-day. One result of this diminution of rough copper tonnage has been to establish a backwardation on the standard copper market in place of the contango which has been usual for many years past, while the rapid appreciation in values has narrowed the margin between Standard copper and electrolytic to about £5. Publication of the October stock figures caused a sharp jump in the price, and between September 30, when cash stood at £53 7s. 6d., and November 2, a rise of £4 10s. was registered, while at the time of writing a further appreciation in values appears to be inevitable. During the same period the Metal Exchange quotation for electrolytic was increased by only £1 12s. 6d. in spite of steady buying by consumers in Europe. On a conversion basis it is hard to see how rough copper can be anything but overvalued at its present price, for even allowing the rebate of 30s. per ton allowed from the contract price of standard copper under the Metal Exchange rules, and adding to it the *pro rata* allowances for deficient produces below 97 per cent. and down to 94 per cent., the cost of refining such material to the degree of purity attained by best select and electrolytic brands would be prohibitive. Imports of rough copper into this country during the present year have fallen considerably below the tonnage of 1926, and so keen has the competition become in Europe to secure reliable brands of Bessemer from Africa and Chile, that prices only about £3 below the wire bar quotation have been asked and paid by consumers in their anxiety to cover their requirements. Scrap copper is also scarce in Europe, but particularly so at the moment in Britain, and, pending the arrival of Bessemer supplies in the New Year, buyers have been compelled to take up warrants of English standard copper and make the best of a bad job, for much of the material is low grade stuff and costly to convert. Earlier in the year the seaboard warehouses at Liverpool, Swansea and Newcastle were heavily drawn upon to provide shipments to France and Italy in connection with sulphate making, and the bulk of the rough copper remaining on warrant is housed in the Midlands, which means that the northern refineries must face an additional item of carriage before receiving the metal. Although world supplies of copper are undoubtedly equal to the present or any likely future demand, there appears to exist at the moment a sectional shortage, which is causing a serious depletion of our holding of rough copper in this country. Forming as it does the basis of dealings on the standard market, this reservoir must be regarded as of prime importance, more especially since the formation of Copper Exporters' Incorporated transferred much of London's predominance in the world of copper to the United States. Compared with the electrolytic quotation standard copper is already priced too high, and signs are not wanting that something like a scramble for supplies will develop should warehouse tonnage be much further depleted. London standard copper quotations have always been looked up to as reflecting with reasonable accuracy the world position of the metal, but such a reputation must suffer should heavy inroads on the "real" backing of the market compel a distortion of the price.

Where the Copper Goes.

Copper has recently confounded the pessimists by rising £6 in as many weeks, during which period heavy sales have been made from America to Britain, France and Germany. At the same time the great reservoir of scrap material has been drawn upon, and in spite of the large quantities of dismantled Post Office wire, ships' pipes and miscellaneous stuff which is always available, merchants have been hard put to it to keep their customers supplied.

Last year the world produced well over a million and a half tons of copper, and this year is not likely to fall behind, for although consumption in America has fallen off Europe is using a good deal more. Britain accounted for 142,000 tons of copper last year, the biggest figure reached since the war years, when we nearly got up to a quarter of a million, and more than 1921 and 1922 added together. America, as well as being the world's biggest producer, can also take care of nearly two-thirds of the production, her total consumption for 1926 being well above 800,000 tons.

Post Office wire is cited above as providing the bulk of secondary copper for smelting, and it is therefore not surprising to learn that very nearly half of the world's total tonnage is used in connection with telephone and telegraph service and electrical installations of all kinds. Bearing in mind that a ton of copper makes about twenty miles of the overhead wire in common use in this country, it can be realised what immense extensions and replacements take place every year in this direction.

In this country alone the G.P.O. disposes of about a thousand tons of copper wire scrap and a similar quantity of bronze every year, which at the rate of twenty miles to the ton would represent 40,000 miles of replacements annually. Allowing for a proportion of thicker gauge wire and cable (which, of course, is composed of strands of plain wire), it would probably be safe to say that the Post Office replaces 20,000 miles on an average from January to December.

Something like 10 per cent. of the world's copper goes to the motor-car manufacturers, while perhaps half that quantity is absorbed for buildings and nearly as much is used for gunmetal bearings. These gunmetal bearings are replaced every few years, and being composed of an alloy in which tin is present, are usually remelted for remanufacture. In pre-war days, when European countries were competing in a race for naval supremacy and the shipbuilding industry generally was more active than to-day, marine requirements accounted for much copper which enters into the manufacture of brass condenser tubes and plates, boiler tubes, steam piping, and all that paraphernalia of "gleaming brass" for which our ships are so famous.

The coming of wireless has, of course, provided a fresh outlet for copper, and probably nearly 10,000 tons is required annually in the making of receiving sets and accessories. The ever increasing use of electricity in our homes means more copper wire and a greatly increased call for copper fires, kettles, etc., while, on the other hand, the gradual elimination of gas and the penny-in-the-slot meter may mean less copper for coinage purposes! Another market of comparatively recent growth is the safety razor, which with the exception of the blade is made entirely of brass, and may account for anything from two to three thousand tons of copper every year.

To give a list of every article, commonplace and little known, of which copper forms the whole or a component part would fill a newspage; but one thing seems certain, and that is the ever increasing use of the metal and the certainty that without it civilisation as we know it to-day would be impossible

Centrifugal Castings for Diesel Engines.*

By J. E. Hurst.

Apart from certain isolated instances where steel and aluminium alloys are used, the principal parts of internal combustion engines, viz., the cylinder liner, cover, piston and piston rings, are generally made of cast iron. It is practically true that cast iron is almost universally used for these purposes. The properties of cast iron as a material for the construction of these parts has been the subject of very critical review and experiment, particularly as a result of the exacting demands of some of the more recent designs of Diesel engines.

The liner and the piston ring drums from which the piston rings are turned are more or less plain cylindrical castings. It is a matter of considerable astonishment to many engineers, how difficult it is to make a plain cylindrical casting, particularly when the casting is required to be machined all over, and to finish without any trace of unsoundness or surface blemishes. The difficulty in the production of castings perfectly sound is a general one, and these difficulties in cylindrical castings are increased by the type of special iron usually desired in such articles as cylinder liners and piston-ring drums, and also by any slight increases in the complexity of the shape of the castings occasioned by the introduction of comparatively simple additions in the way of flanges, ribs, lugs, bosses, ports and waterway passages.

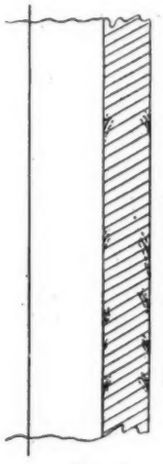


FIG. 1.

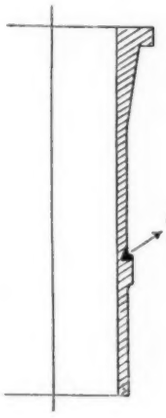


FIG. 2.

In order to make these difficulties understandable it is necessary to consider briefly the progress of cooling and solidification of such castings. Such castings are generally cast vertically, but whether cast vertically or horizontally, the mould itself consists of an annular cylindrical cavity in sand which is filled with liquid cast iron in the process of casting. Certain initial difficulties arise largely from the method in which the molten metal is introduced into this cavity. Two typical examples by way of illustration might be given. For example, in the case of cylinders cast vertically in which a downgate runner is used, allowing the molten metal to enter the bottom of the mould and rise up, there is a danger of unsoundness arising from the dirt and washings off the face of the mould being entrapped in the rising metal in the manner indicated in Fig. 1. This can be, and is, of course, overcome by top pouring. There is always a danger of dirt and similar material being collected in re-entrant portions of ribs and flanges on the rising side, as indicated in Fig. 2. As can be readily imagined, these defects in a small degree are only brought to light after the casting has been completely machined, and whilst they are what might be described as mechanical defects they are a type of defect which must in the ultimate be ascribed to the method of casting.

The inherent defect of unsoundness in castings takes the form of internal porosity or sponginess and blowholes, and such unsoundness is the most important difficulty which confronts the founder in the successful production of castings. From the engineer's point of view unsoundness in any form is a most annoying defect in that it is usually revealed only after he has spent considerable time and money in machining the castings.

The modern view as to the cause of such inherent unsoundness and the view which is rapidly gaining ground is that it is to be ultimately ascribed to the manner in which the molten metal solidifies in the mould. The older view ascribing unsoundness, particularly that due to blowholes, to the gases evolved from the mould as a result of the contact with the hot metal is being steadily superseded. It has always been difficult to understand, except in the very obvious case when molten metal is poured into an exceptionally wet mould, how the mould gases could penetrate into the interior of the casting through the solid walls which must be formed almost instantaneously after the metal is introduced into the mould.

The modern views on the question are more readily understandable when the true character of liquid cast iron is realised. Liquid cast iron is really very much like soda water and contains a large quantity of dissolved gases. Even in the solid state it is quite common to find cast iron containing three times its own volume of dissolved gases, which incidentally consist of hydrogen, nitrogen and the oxides of carbon. Exactly as in other liquids, the solubility of these gases is greater in the liquid state than in the solid state and furthermore, the solubility is lessened with increasing temperature. The presence of these dissolved gases is an important factor and they are undoubtedly responsible for by far the greater majority of cases of unsoundness in castings.

The behaviour of the liquid metal on cooling from the molten state in special respect of the dissolved gases can be followed clearly by bearing the above facts in mind. The liquid metal at the time of casting may or may not be saturated with dissolved gases. As the temperature falls the solubility of the gases increases and the amount of gas in solution becomes considerably less than the saturation value until the casting commences to solidify. At this point, owing to the marked decrease in solubility accompanying the change from the liquid to the solid state, the gases are evolved from the solidifying portion of the mass and becomes more and more concentrated in the remaining liquid portions. As solidification proceeds the gases concentrate in the last remaining portions of the liquid metal, and these contain the whole of the dissolved gases in excess of the difference in solubility between the liquid and the solid state. It may be that the concentration of these gases in the manner indicated results in the saturation value being reached in the last portions of liquid metal in which event the excess gases will be evolved and blowholes and unsoundness result.

Now let us imagine this taking place in a cylinder-liner mould. The mould full of liquid metal containing gas commences to solidify practically simultaneously on both the external and internal surfaces, and solid walls or shells of metal are formed with the liquid metal remaining in between. As the solid metal increases the gases are concentrated in the still remaining liquid portions of the metal in the centre of the radial thickness of the casting, and if the concentration reached is high enough, the gases evolved must either find their way out through the whole length of the casting or be entrapped in the radial thickness of the wall. This is clearly illustrated by Fig. 3 (A).

In an exactly identical manner there is a tendency for those constituents which are insoluble, such as manganese sulphide, to segregate into the last portions of the liquid metal to solidify, and for the same reasons, all the segregations are to be found in cylindrical castings in or about the centre of the radial thickness.

With the possible exception of some of the type-founding alloys, cast iron (in its ordinary commercial grades) has the lowest total shrinkage of commercial casting alloys. This is one of the fundamental properties of cast iron which goes to make it the most successful alloy for casting purposes. In spite of this, cast iron undergoes an appreciable amount of total shrinkage in volume in changing from the liquid state to the solid state. This shrinkage in volume makes its presence felt in the production of castings by its tendency to produce a condition of unsoundness technically described as "Piping." The formation of piping in cylindrical castings can be readily understood from the brief description of the solidification of such castings given above. The marked difference in shrinkage due to the change from the solid to the liquid condition is made good in the first layers to solidify by the withdrawal of sufficient molten metal from the remaining liquid metal in the centre. The continuance of this results in a state of affairs in which final solidification takes place with insufficient metal to completely fill the centre portions; hence the contraction cavity or pipe as indicated in Fig. 3 (A).

Fortunately the troubles that arise from the solidification of liquid metal in cylindrical moulds can be surmounted largely by the use of a feeder head. This takes the form of an extension in the length of the casting and is usually arranged to be of a greater mass, with the result that the metal in this portion is the last to solidify, maintaining a free liquid path for the gases of supersaturation, and making good the supply of metal for the shrinkage deficiency.

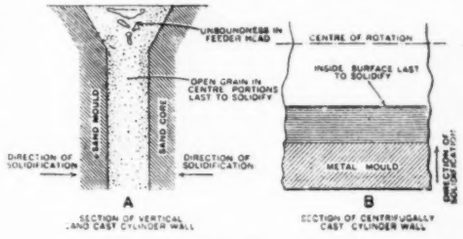


FIG. 3.

Whilst the feeder head has the effect of generally removing all tendency to such visible unsoundness as blowholes and marked porosity, it does not remove all traces and character of unsoundness. It is well known to all engineers that in machining cylinder liner castings, even though visible unsoundness is not present, the further the machining approaches the centre of the thickness the more coarse grained the material becomes, the strength properties fall off considerably and the tendency to porosity increases. There is no doubt that the phenomenon of the segregation of the dissolved gases plays an important part in the production of this condition, and in spite of the absence of visible local blowholes and unsoundness it is possible that the open tendency is of a similar nature to the general unsoundness referred to above, and is partially due to the segregation of the dissolved gases.

The other principal factor in the production of this condition is the variation in the rate of cooling. As the interior of any solidifying mass of metal is approached the rate of cooling becomes slower. The slower rate of cooling is invariably accompanied by the formation of larger crystals or grains, and hence the grain size is larger in the interior portion. There is also a change in the composition due to this same fact, and there is a tendency for there to be less combined carbon and more graphite as the centre is approached.

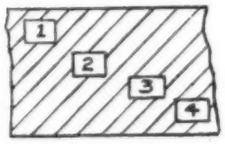
* A Paper read before a Meeting of the Diesel Engine Users' Association, Mr. Geoffrey Porter presiding.

Whilst the general tendency to unsoundness towards the centre can often be observed in the fracture it is essential to point out that there is no *a priori* reason why it should be visible. Obviously its visibility depends upon the extent of the tendency to unsoundness in the first place, and we may only expect to see it in the fracture when the extent is great. The real criterion lies in the mechanical strength determinations, and when these are examined, particularly by such a sensitive method as the ring test to be described later, this tendency is revealed. An example is given in Table I.

Table I.

No. of sample.	Tensile (tons per sq. in.)	Composition of casting.	
1	14.5	C.C.	0.82
2	12.8	T.C.	3.06
3	12.6	Si.	1.04
4	15.7	Mn.	0.86
		S.	0.15
		P.	0.35

Position of samples.



It must not be inferred from this brief survey that sound and serviceable castings cannot be obtained. As we all know, the exact opposite is the case, and in view of all these inherent difficulties, the very fact that sound and serviceable castings are obtained is a testimony to the skill and knowledge of ironfounders. In spite of all the improvements made in cast-iron cylinder liners and piston rings the methods adopted in casting these liners remain fundamentally the same as in the early days of ironfounding and there has been no alteration in the method of production of cylindrical castings until the advent of the centrifugal casting process.

The Centrifugal Casting Process.

The centrifugal casting process introduces a new method of casting cylindrical articles and eliminates the inherent defects of the vertical sand casting methods in an ingenious manner. The broad principles embodied in the centrifugal casting process are now familiar to most foundrymen and engineers, and essentially consist of the pouring of the molten metal into rapidly rotating moulds, rotating about the horizontal axis. As a result of the rotational velocity acquired by the molten metal, it takes the outer form of the mould and the inner form solidifies truly cylindrical, of a diameter governed either by the amount of metal introduced or by the internal diameter of the annular shaped end walls of the mould. This process is now extensively adopted for the production of cylindrical castings for such purposes as cylinder liners, piston ring drums, piston valve liners and many other types of cylindrical castings where high quality is required, both in the metal and as a casting. A machine for the production of castings up to 3 ft. long and 3 ft. diameter designed under the Hurst-Ball patents is operated at the works with which the writer is connected.

The most outstanding advantage of the centrifugal casting process for the production of cylindrical castings is the certainty of obtaining a casting of complete soundness. A brief comparison of the method of solidification of the molten metal during the production of a centrifugal casting with the method already described in ordinary sand casting will serve to make this clear. The sketch "B" in Fig. 3 by comparison with "A" clearly demonstrates how the metal is applied to the surface of the rotating mould.

In the centrifugal process the mould is filled with metal in a direction at right angles to that in which the filling takes place in the vertical sand mould, and solidification of the metal commences from the outside surface only and proceeds across the radial thickness of the casting progressively until the whole is finally solid; the inner surface layers being the last to solidify. If we imagine the instant at which solidification commences to occur, the metal lying against the mould wall is liquid and has acquired the rotational velocity of the mould. Under these conditions a centrifugal pressure gradient is established across the radial thickness of molten metal, the pressure being at a maximum in the outside diameter layers of molten metal and zero on the extreme inside diameter layers. This maximum pressure is often of the order of 500 lb. per sq. in. The dissolved gases liberated by the solidifying layers which first commence to solidify on the outside surface must make their way through the radial thickness of still liquid metal. It will be noted in passing, that this is a much shorter path than the vertical length of the casting in the vertical sand casting case. The passage of the gases through the radial thickness is assisted so enormously by the steep pressure gradient that we may say the gases are actually forced out by the centrifugal pressure and that for all practical purposes it is impossible for blowholes or internal unsoundness to exist in castings made by this method.

Normally a metal mould is used in the centrifugal process and as a result of this, a certain increase in the rate of cooling over and above that normally experienced in sand castings is obtained. Whilst this increased rate of cooling is partially responsible for the extreme fineness of grain and closeness of fracture, it is not the whole story, as will be presently shown. It is well known that the rapid agitation of crystallising liquids has a marked influence in producing fine crystal grains, and there is not the slightest doubt that the rapid rotation of the molten metal is largely responsible for the closing up of the grain size experienced in centrifugal castings. It must be admitted that for fineness of graphite size, centrifugal castings have never been surpassed.

The two most important advantages of the centrifugal process over vertical sand casting processes for the production of cylindrical castings are the soundness and freedom from internal defects and the extreme closeness and uniformity of grain size which is, of course, reflected in the mechanical strength properties of this material.

Chemical Composition and Properties of Centrifugal Castings.

Centrifugal castings are now extensively adopted for piston ring drum manufacture, and practically all the small diameter rings used in the automobile engines and the smaller internal combustion engines are made by this process, and their application to the larger internal combustion engines and Diesel engines for this same purpose is rapidly increasing. The material requirements of automobile piston rings are covered by the British Engineering Standards Association Specification No. 5,004, and the Air Board Specification 3K.6, which have been evolved as a result of considerable experiment and investigation undertaken jointly and severally by the above-mentioned bodies. The chemical composition requirements, which are the same in both specifications, are as follows:—T.C., not more than 3.50; C.C., between 0.45 and 0.80; Si, 1.80 and 2.50; Mn, 0.40 and 1.20; S, not more than 0.12; and P, not more than 1.00 per cent.

The mechanical test requirements consist of a tensile test and an elasticity value. The tensile test is performed on a ring cut from the drum, to an approximately square section or to a section approximately that of the finished ring. The ring is split and pulled apart in a testing machine by a load applied at opposite ends of the diameter which is at right angles to that through the gap. The ring must withstand a stress of at least 16 tons per sq. in. before fracture, calculated from the following formula:—

$$S = \frac{P \times D}{1{,}200\ bt^2}$$

Where S = stress in tons per sq. in.; D = external dia. of closed ring in ins.; P = load in lbs.; b = width of ring in ins.; and t = radial thickness of ring in ins.

The elasticity of the material is the property which determines the spring in the ring or the pressure it exerts on the cylinder wall. It is, of course, well known that the elasticity value of cast iron is not constant over a stress range as in the case of steel, but varies progressively with an increase in stress. In view of the fact that the dimensional specifications for piston rings include the minimum and maximum cylinder wall pressures exerted by the rings, which are calculated from a formula in which the elasticity value determined under certain well-defined conditions is used, it is necessary to embody this elasticity test in the material specification. The elasticity test requirements of the specification determined under these defined conditions is referred to as the E*n* value, and must not be less than 15.5 million lbs. per sq. in. This is an exceptionally good value for cast iron, and centrifugal castings exceed this by an amount of generally from 1 to 2 million lbs. Broadly speaking, the total carbon is the controlling factor, and high E*n* values are generally associated with low total carbon.

The requirements of the larger internal-combustion engine and Diesel engine piston rings have not been standardised in the same manner. It is customary for centrifugal casting manufacturers to endeavour to work to the lower limit of silicon content given in the above specification for the larger rings required for these purposes, and some typical results obtained on large Diesel engine rings are given in the Table II.

Table II.

No.	C.C. Per cent.	T.C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.	Tensile (tons per sq. in.)	E*n* value (million lbs. per sq. in.)
1	0.60	3.55	1.79	0.75	0.10	0.85	17.5	16.7
2	0.55	3.40	1.80	1.06	0.12	0.76	19.6	17.5
3	0.62	3.57	2.02	0.66	0.10	0.55	19.8	17.5
4	0.70	3.38	1.96	0.70	0.07	0.40	20.4	18.0

Resistance to Wear and Heat Conditions.

After soundness and freedom from internal defects, two of the most important properties required in cylinder liners are resistance to wear and to heat conditions. A very large amount of research and investigation has been devoted to these properties, in so far as they affect internal-combustion engines. It is not within the scope of this Paper to deal with these in intimate detail, but in the present state of our knowledge of this subject there are certain broad relations which emerge from the mass of experimental investigation and which must be apparent to many who have followed this work closely, and which are of importance at this stage of the Paper.

The first relationship of very great importance we owe to the extensive work of Dr. Mellanby, that the resistance to wear and resistance to growth or distortion under heat conditions are almost synonymous terms. The second broad relationship is that both the resistance to wear and resistance to growth are proportional to a strength factor which is probably the shear strength. For our present broad purposes it will suffice to say that there is a relation between the resistance to growth and wear and the tensile strength in cast iron. These broad relations are of importance, and are particularly fortunate to the metallurgist who is called upon to produce material giving satisfactory behaviour towards these conditions, as it follows that any feature of the composition or constitution of cast iron which gives or improves one or other of the three related properties—resistance to growth, wear or tensile strength is likely to have a similar effect on the remaining properties.

Further investigations have shown that one or other of these properties is influenced to the good by the following:—(*a*) Low silicon content; (*b*) low total carbon content; (*c*) high combined carbon content; (*d*) grain size; (*e*) condition of the combined carbon constituent; and (*f*) certain alloy additions. The first three of these items are of major importance at the moment. The last item relating to alloy additions will not be dealt with in this Paper.

Bearing in mind that cylinder liners are required to be machinable and also sound castings, it follows that if we can use an iron of the lowest silicon and total carbon content, coupled with the highest combined carbon content compatible with commercial machinability and soundness, this iron

FIG. 4.—GROUP OF PISTON VALVE LINERS CAST BY THE SPUN-SORBITIC PROCESS.

will have high resistance to growth, wear and tensile strength. It does not follow *a priori* that such an iron will have, say, the optimum of these properties; for example, such an iron may not have the highest tensile strength. This will depend upon its method of production. It is known from the above relationships that if the tensile strength were increased, maintaining the other features constant, we should expect still better resistance to wear and growth. The strength is primarily influenced by the grain size, and it follows, therefore, that if the above conditions are obtained, accompanied by a very small grain size, the resistance to wear and growth are still further improved.

Spun-Sorbitic Centrifugal Castings.

The above, what might be termed theoretical reasoning, finds practical expression in the further development of the centrifugal casting process introduced by the author at his works under the

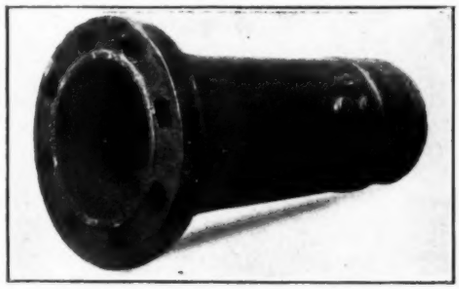


FIG. 5.—OIL ENGINE LINER CAST BY THE SPUN-SORBITIC PROCESS.

title of Spun-Sorbitic. This development is designed to enable cylindrical castings to be produced by the centrifugal process in low silicon, low total carbon irons with the maximum of combined carbon compatible with commercial machinability. In this method, as applied to the production of large internal-combustion engine cylinders, the metal mould normally used in the centrifugal process is replaced by a refractory sand-lined mould made up in the ordinary way, using the skeleton pattern slit for sweeping boards. The mould is made up in a special container, capable of being mounted on the centrifugal casting machine. Exactly as in the case of the metal mould, no core is used, and the mould is spun about its horizontal axis, and the molten metal is introduced in a similar manner. Thus all the advantages by way of solidification of the metal in the centrifugal process as and against vertical sand casting are secured. The refractory mould enables the low silicon content irons commercially machinable to be obtained easily, and, in addition, enables modern Diesel engine liners with ports, waterway passages and flanges to be dealt with, which would otherwise be unpracticable in metal moulds.

When the material used in this process is allowed to cool down normally, the whole of the combined carbon is found to be in the structural condition known as pearlite. Cast iron of this composition when quenched in water is hard, like steel, due to the fact that this constituent exists in the form of martensite. Again, as in the case of steel, if the rate of cooling is hastened somewhat above the normal an intermediate structure between pearlite and martensite is obtained, still freely machinable, known as sorbite. In this new process the casting during cooling down is subjected to the action of a wet-air blast, suitably regulated. The hastened cooling resulting from this treatment results in this sorbitic structure. This is distinctly advantageous, since it is known that this structure is highly resistant to wear. Some typical examples of castings are shown in Fig. 4 (locomotive piston-valve liners) and Fig. 5 (oil engine cylinder liners). The cored-out exhaust ports and passages in these castings will be noticed.

It is of considerable interest to note that the special treatment is applied to the whole of the inside surface of the casting, that is, the wearing surface. Moreover, the grain size does not suffer as a result of the slower cooling due to casting in a sand mould. This must be taken as evidence that the rotation and agitation of the liquid metal is of primary importance in determining the fine grain size of castings made by the centrifugal process.

The chemical composition and properties of the Spun-Sorbitic castings illustrated is given below:—T.C., 3.00; Gr., 2.03; C.C., 0.97; Si., 1.31; Mn., 0.42; S., 0.11; and P., 0.34 per cent. Tensile strength determined on two rings in accordance with B.E.S.A. Specification No. 5004:—(*a*) 28.9 tons per sq. in., and (b) 26.4 tons per sq. in.

The high tensile strength of this material and also the high *En* value will be noted. It is perfectly legitimate to draw the conclusion from these figures that the material will possess, in a high degree, the properties of resistance to wear and growth.

It should also be added that the cooling treatment is likewise applicable to the castings produced by the ordinary centrifugal process in metal moulds with a resulting sorbitic structure possessing a high degree of resistance to wear. This new development in this direction is of special interest in the production of automobile engine sleeve and cylinder barrels.

In conclusion, the author hopes that these brief notes on the development of the centrifugal casting process as applied to internal-combustion engine castings will be of interest and will serve to illustrate in some small measure the work that is being done by foundrymen and metallurgists to meet the requirements demanded by engineers for Diesel engine users. Finally, the author must take this opportunity of expressing his thanks to the Directors of Messrs. Newton Chambers & Company, Limited, for permission to utilise the results and information given.

THE GRINDING AND PULVERISING offices of International Combustion, Limited, 11, Southampton Row, London, W.C., have recently taken orders for equipment for various parts of the world, including Raymond pulverisers, Ro-Tap testing sieve shakers, and Hardinge conical ball mills.

Hardness and Machinability of Cast Iron.

The Brinell test is generally used in practice to determine the machinability of cast iron. Recently W. Melle* made investigations in order to find out some relationship between these two mechanical properties. In his experiments Melle used the drilling machine constructed by Kessner, which under definite working conditions gives a diagram in which the abscissa represents the depth of the hole drilled out with a magnification of 5.5 and the ordinate the number of revolutions made by the drill (50 millimetres = 100 revolutions, Fig. 1). In order that the experimental

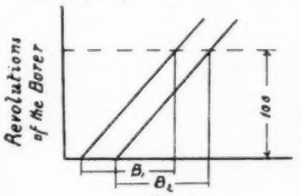


Fig. 1.

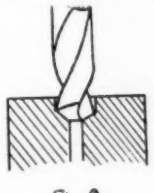


Fig. 2.

results can be compared with each other, the working conditions of the machine must be kept constant. In the experiments in question these conditions were:—(1) Pressure exerted on the drill = 55kg.; (2) diameter of the drill = 10 millimetres; (3) cutting speed = 10 metres per minute; (4) cutting angle of the drill = 120 deg.; (5) no cooling of the drill; and (6) in order to eliminate the influence of the cross edge of the drill before starting the experiment a hole was drilled into the sample, the diameter of which corresponded to the length of the cross edge.

The experiments were made with various kinds of cast irons, the Brinell hardnesses of which were within the range from 90 to 240 kg./mm².

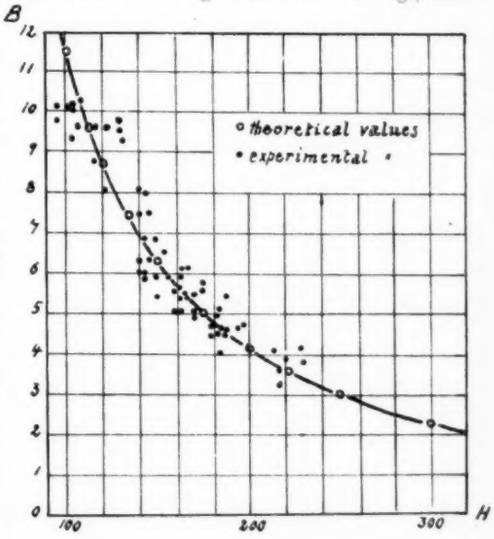


Fig. 3.

In order to control the cutting power of the drill after each experiment there was drilled a cast iron the Brinell hardness of which was 150 kg./mm². When the results of these intermediate experiments differed from each other by 6 to 7 per cent. another drill was used in the following regular experiment. From Fig. 3 it can be seen that the experimental results practically agree with the curve which represents the equation: $B \cdot H^{1.47} = \text{constant} = 10{,}000$.

where

B = machinability = length of the abscissa in centimetres after 100 revolutions of the drill.

H = Brinell hardness in kg./mm².

The experiments show that it is quite possible to examine the machinability of cast iron by the Brinell test, but the relationship between these two properties is not a linear one.

* Giesserei-Zeitung, 1927, No. 17, pp. 485–6.

Metallurgy in the Electrical Industry.

"Some Metallurgical Problems of the Electrical Industry" was the title of an address given by Mr. C. C. Paterson, O.B.E., Director of the well-known research laboratories of the General Electric Company at Wembley, before the London Local Section of the Institute of Metals.

In the course of his address, and speaking on the question of conductors, the lecturer remarked that one of the heaviest items of expenditure in the electrical industry, and one which reflected itself directly in the cost of current to the consumer, was the capital expenditure on transmission. In the case of underground cables the copper may be taken as presenting for high tension some 20 per cent. of the cost, and for low tension about 50 per cent. For long-distance overhead transmission the cost of the copper was of the order of 45 per cent. The remaining cost lay in the supporting towers with their insulators, the spacing of which depended upon the tensile strength of the copper conductor.

A further complication occurred in the more important schemes of overhead transmission at high voltage owing to the fact that the diameter of the conductor must be kept over a certain minimum, as otherwise large power losses would occur through "corona" discharge, and much ingenuity was being expended in the development of tubular conductors. It was safe to say that these would present metallurgical problems.

"Are we wedded indefinitely to copper or aluminium as we know them to-day, or may we contemplate the possibility of a copper with the same conductivity and higher tensile strength—or is it beyond the bounds of possibility that metallurgical research would yield a high conductivity alloy to rival copper?" The author had no specific proposals to make, but he did not believe that the possibilities of the lighter metals, beryllium, lithium, boron, aluminium, when alloyed, had yet been fully investigated.

Magnetic Properties.

The electrical industry made use of several different magnetic properties,—so that not only did it present a complex specification to the metallurgist, but often required forms of excellence which were hard to obtain in the same material, *e.g.*, permeability and resistivity. The problem of improving materials magnetically was more complicated than that of improving their conductivity.

Composition.

With regard to the composition of magnetic materials, the influence of impurities loomed very large. In particular, the researches on the effect of carbon in iron had shown that element to possess an enormous and controlling effect on the permeability and hysteresis loss so that by reducing the carbon percentage to 0.002 per cent. material of many times the permeability and many times less losses could be produced. The method, of course, was that of vacuum melting.

Nickel iron alloys with about 75 to 80 per cent. nickel, and by no means extraordinarily pure, show ten times the permeability and negligible losses as compared with the purest iron. The addition to these alloys of a few per cent. of tungsten or molybdenum apparently increased the permeability still more, and at the same time increased the electrical resistance.

Such results lend a new significance to the discovery, by now somewhat old, that the iron-cobalt alloy with about 30 per cent. cobalt had a 25 per cent. higher saturation value than iron. Could such a material be produced cheaply and with reasonable hysteresis loss and permeability it would be of immense value in rotating machinery.

Heat Treatment and Mechanical Working.

Generally speaking, mechanical work, such as rolling or drawing, was injurious to magnetic properties and annealing improved them. It was probable, too, that crystal structure was of importance to magnetic quality, but so far experiments on signal crystals were not easy to reconcile with one another, and the whole subject was in an elementary stage of investigation.

From the practical point of view, it was probable that heat-treatment and methods of manufacture, adapted to reduce impurities, were the main points wherein production lags behind laboratory research, and where, therefore, development was required.

Impurities.

Referring to the effects of impurities upon the properties of materials, the lecturer urged the importance of their investigation, even of the most minute traces, say, less than 0.01 per cent. The evolution and application of methods of detecting and eliminating the last traces of impurities in materials produced for study in the laboratory was likely to prove a most fruitful subject of research, and should have theoretical as well as practical interest. The spectroscope (visible, ultra, violet and X-ray) was, of course, an essential tool in such researches.

Gases.

Touching upon the effects of foreign ingredients present as impurities, the author pointed out that the presence of gases in metals such as nickel, molybdenum, and tungsten had impressed itself in recent years on all those who have had to deal with high vacua in the manufacture of incandescent lamps and thermionic valves. For the satisfactory operation of those devices it was essential that no gas should be evolved within the glass envelope. In many cases the metal parts when in use are maintained at high temperatures—nickel anodes, for example, being used at 700 to 800 deg. C. Commercially pure metals were quite unsuitable for use as received, and a two-hour treatment *in vacuo* until the gas pressure falls to four-thousandths of a mm. of mercury was usually necessary to remove the bulk of the gases contained in the metal.

In considering the effect of gases on electrical properties of metals we are chiefly concerned with gases present in solution or in the grain boundaries. The presence of blowholes or other unsoundness in metal affects the electrical conductivity in such an obvious manner that we may dismiss this class of gaseous impurity. Soluble impurities have a marked effect on the electrical conductivity, and, for this reason, the presence of dissolved gases in metals was often more easily detected by changes in the electrical properties than in the mechanical properties. Comparatively little data were available, however, for the common metals, possibly because of the practical difficulties of removing gas on an industrial scale. The magnetic properties of metals appear to be influenced by the presence of dissolved gases, although no quantitative data were available.

Non-metallic impurities affect the electrical properties of metals in a degree depending upon their distribution. They may be looked upon as non-conductors in comparison with the metals in which they occur. The effect of non-metallic impurities on the magnetic properties of iron has been investigated, amongst others, by Yensen. Sulphur increases the hysteresis loss in pure iron, and in the 4 per cent. silicon-iron alloy, in proportion to its concentration, whilst the effect of phosphorus is more complex owing to its partial solubility.

Oxides and other non-metallic impurities all exert injurious effects on the magnetic properties of iron, owing to the comparatively large volume which a small percentage by weight must occupy.

The presence of *metallic impurities* generally results in a decrease in the electrical conductivity of metals, although the magnitude of the effect varies considerably in different cases. The effect of arsenic on the conductivity of copper has recently been studied by Hanson and Marryat. Their results, as follows, are of considerable importance in view of the use of arsenic as a deoxidiser for copper:—

Per cent. Arsenic.	Mass conductivity.
0.00	102.1
0.053	85.5
0.093	76.7
0.36	44.9
0.60	33.4
0.86	25.7

Arsenic is soluble to the extent of about 7 per cent. in copper, and it will be noticed that as little as 5 parts in 10,000 reduces the conductivity by 15 per cent.

The temperature coefficient of resistance was of great practical importance in the case of alloys used for making standard resistances. To be satisfactory for this purpose manganin should have a temperature coefficient of less than 1 × 10-5 microhm cm. per deg. C. This alloy has approximately the following composition:—Copper, 83.5; manganese, 13.0; nickel, 3.0; and iron, 0.5 per cent. Variations in the proportions of the constituents affect both the resistivity and the temperature coefficient. The thermo-electric properties of alloys are also readily affected by the presence of soluble metallic impurities, and to avoid variations from batch to batch in manufacture careful control is necessary.

High-Temperature Alloys.

What the electrical industry wanted from the metallurgist was an alloy in the form of wire which would hold up indefinitely in service to higher temperatures than at present, remembering that every 50 deg. C. was worth having. By "holding up" he meant that, firstly, it must not develop local hot spots when heated by electric current; secondly, for certain uses it must remain stable, *i.e.*, be free from sag or creep, and it must also be producible at an economic price. It was most important to devise and to establish tests for the first two of these qualities which would permit one alloy to be compared with another for the effectiveness in high-temperature electric heaters.

In their own laboratories they had been making a study of the subject and trying various tests, having regard also to proposals from other quarters, mainly America and Germany. Details of this work would shortly form the subject of a more formal publication by Dr. Smithells and Mr. H. V. Williams.

Submerged-Flame Combustion.

In the course of a Paper read by Mr. Norman Swindin at a conference held on December 1, at the Chemical Society's Rooms, the author remarked that in the light of our present knowledge of flames and combustion, it is comparatively easy to make a flame of any combustible substance burn in any atmosphere and liquid, but to make a saleable article, the burner must be robust, simple and fool-proof. The conditions under which steady combustion takes place beneath a liquid are:—

(1) The fuel must be liquid, gaseous, or sufficiently divided if a solid, so that it can flow or be blown through small orifices and pipes.

(2) The air or oxygen-containing gas must be carefully controlled to form a constant combustible mixture.

(3) The fuel and the air must be thoroughly mixed and passed through a tube of such a size that the velocity of flow is greater than that of the rate of propagation of flame which depends on the composition of the gas; it is usually 3 ft. per sec.

(4) The combustible mixture is to be burnt in contact with a hot spot or incandescent surface in order to increase the rate and ensure completeness of combustion and to keep the flame alight.

(5) The burner chamber is to be of such construction and made of such materials that a constant temperature of the walls is maintained below that of fusion of the lining and so high as not to cool a portion of the gas below its combustion temperature.

(6) The burner is to be used in such a way that the products of combustion do not affect the vessels and plant and the substances being evaporated.

(7) The working pressure is to be adjusted so that the partial pressure of the steam does not unduly lose the heat.

Consideration of the above conditions will enable one to form an opinion about the various designs which have been proposed from time to time.

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Trade Talk.

THE LONDON, MIDLAND AND SCOTTISH RAILWAY COMPANY have placed orders in the Cleveland area for 6,250 tons of steel rails.

PHILIPP & LION, metal and mineral merchants, 2, Broad Street Place, E.C.2, have removed to more commodious offices at 28, Finsbury Square, London, E.C.2.

THE FIRST SUN-RAY CLINIC for miners was opened at Sherwood Colliery, Mansfield, in the presence of a number of eminent medical men and others who are supervising this experiment for preventing disease in the industrial population. The clinic is situated in the pityard, and its cost, excluding the installation of electric light, is £1,300.

W. RICHARDS & SONS, LIMITED, of the Britannia Foundry, Middlesbrough, have issued their yearly chart of iron and steel prices. It shows the fluctuations in prices of pig-iron, steel plates, rails and sections, bar iron, iron castings, rivets, etc., from the year 1914 to the present date, and a space is left for keeping the chart up to date until November, 1928.

SWAN, HUNTER AND WIGHAM RICHARDSON, LIMITED, Wallsend, have recently received an order from the Hungarian Levant Company for a new cargo vessel of between 6,000 and 7,000 tons deadweight. The vessel will be built at the firm's shipyard at Southwick. It is understood that the engines will be constructed by the North-Eastern Marine Engineering Company, Wallsend.

AT A MEETING of the Industrial group of M.P.'s at the House of Commons on December 1, Mr. David Bremner, director of the British Engineering Association, spoke on the relationship between the engineering trades and the iron and steel industry. Mr. Bremner said he was quite satisfied that the iron and steel industry could prepare a case for safeguarding with the assurance of the engineering industry that prices level would not be raised.

THE SOUTH DURHAM STEEL AND IRON COMPANY, LIMITED, were obliged practically to close down their works at Stockton on Saturday on account of bad trade. This has made several hundreds of men unemployed. Work has practically ceased at the plate mills, the rolling mills, and the moulding shops, but a few men are still engaged at the sheet mills, which, it is anticipated, will be able to carry on to the end of the year. The only department in this large undertaking which will then be left operating will be the new tube works and the galvanising shop.

FOR THE SECOND MONTH in succession the output from the Clyde shipbuilding yards has been over 70,000 tons. November, with its 26 vessels of 73,628 tons, is the best month of the year. During September, October and November the tonnage launched aggregated 203,432 tons, which is actually 270 tons greater than the total production of the preceding eight months. Up to date 196 vessels measuring 406,592 tons have been put into the water; the figures for the corresponding period of 1926 were 114 vessels and 254,866 tons; and for 1925, 210 vessels and 486,130 tons.

THE FOLLOWING CHANGES have been made in the Australian tariff in regard to iron and steel products: Tariff item 136, (C) (1) Iron and steel—bar, rod, other than wire rod in coils, angle, tee; bars of fancy pattern in the state in which they leave the roller, per ton, British preferential tariff, £3 10s.; intermediate tariff, £5; general tariff, £6. No. 154 (A) Railway and tramway rails weighing 50 lbs. per yard and over, per ton, £2 10s., £4 5s., and £5 respectively. No. 155. Rolled iron or steel beams, channels, joists, girders, columns, trough and bridge iron and steel (a) not drilled or further manufactured, per ton, £3 10s., £5, and £6 5s., respectively; (b) drilled or further manufactured, per ton, £3 10s., £5, and £6 5s., respectively; and *ad val.*, 25 per cent., 30 per cent., and 35 per cent., respectively.

SIR GEORGE HUNTER, interviewed concerning the Duke of Montrose's suggestion to form a pool among the shipbuilders, said he was afraid that the Duke's scheme would not be practicable, and mentioned that years ago a pool was attempted among Wear shipbuilders. Another Tyne shipbuilder stated that for two years builders had been considering a pool with a view to effecting economies. The pool visualised by English shipbuilders was not one of particular areas, but of the whole shipbuilding activities of England and Scotland. It was an arrangement whereby costs could be reduced to a minimum, and the scheme could be carried out under the direction of a controller who would direct economies from the centre, so that all shipbuilders would be equally benefited. It would not eliminate the spirit of competition, and there was nothing in such an amalgamation to prevent shipowners from placing their orders where they wished. The scheme did not mean a pooling of capital, but only the elimination of middle people who, by the operation of the custom of commissions and other means, kept prices of materials high.

THE POWER-GAS CORPORATION, LIMITED, have acquired the Imperial Boiler Works, Stockton, belonging to Messrs. Thomas Sudron & Company, Limited.

REPRESENTATIVES OF THE Staffordshire Iron and Steel Institute, the Birmingham Metallurgical Society, and the Birmingham section of the Institute of Metals attended the second annual dinner in Birmingham on Saturday, arranged by the Co-ordinating Committee. Dr. Douglas H. Ingall presided. In proposing the toast "The Co-ordinated Societies," Mr. C. Grant Robertson (Principal of the University of Birmingham) pointed out that when man came to use metals he had made a great advance in his progress toward civilisation. The growth and progress of Society could be gauged by the interest taken in metallurgical knowledge, science and industries. Metallurgy had played a great part in the revolutionary changes of the past years.

A MERCHANT FIRM points out that Empire smelters are at present handling 80 per cent. of the world's tin supplies, so that the marketing of tin has virtually become a British monopoly; and it might be inferred that this industry is centred almost entirely in the East. As a matter of fact, a very large and important section of the tin-smelting industry is to be found in Liverpool, a circumstance which serves to emphasise the essentially British character of this great industry. Two other points may require elucidation. Sir Robert Horne has referred to the extensive system of obtaining tin from alluvial deposits by means of dredging. Moreover, in emphasising the successful treatment of ground returning no more than half a pound of tin oxide to the cubic yard, and it is suggested that the inference is that the Empire's alluvial deposits are of uniformly low grade. In Nigeria practically the whole output of alluvial tin is obtained by methods other than dredging, and that as regards Malaya probably not more than half the production is obtained by dredging, whilst both in Malaya and in Nigeria much of the alluvial still yields one pound of tin and upwards to the yard.

AT THE ANNUAL DINNER of the Institution of Mechanical Engineers (North-Western Branch), held recently at the Engineers' Club, Manchester, Mr. W. L. Hichens (chairman of Cammell, Laird & Company, Limited) described the engineering profession as the finest in the world. He said that if the industries of this country were in a depressed condition to-day—and he was afraid they were—it was not the fault of the engineering profession nor, he ventured to say, of employers generally. It was the fashion to accuse employers in this country of being behind the times, unenterprising, and of having made a great number of mistakes, but he did not suppose they had made more than employers in other countries. The plain fact of the matter was that in this country our industries had had to struggle against unforeseen circumstances which were altogether beyond their control. It was very easy to tumble into the abyss of a world-wide war, but very difficult to climb out again. We had still a stiff climb ahead of us, and in that connection the speaker deprecated the utterances of those who, in after-dinner speeches, said they could see the dawn of a better era ahead and that in a few months there would be a great boom in this land. But he did see encouraging signs. He did not want to suggest that we should get out of our difficulties in a hurry, but he did see three definite signs of encouragement.

Personal.

MR. W. VINCENT WAITE, M.I.MECH.E., A.M.I.E.E., has been appointed General Works Manager of the Low Moor Works of Messrs. Robert Heath & Low Moor, Limited, Low Moor Iron Works, Bradford.

MR. W. P. HUTCHINSON has left the head office of Dorman, Long & Company, Limited, to take up an important position in Calcutta under the same firm. He acted as personal assistant to Mr. Arthur Dorman when he became managing director of the firm.

SIR ROBERT HADFIELD, BART., has been specially invited by Sir Alfred Mond to form one of the group of influential employers of labour who will shortly sit with representatives of Labour nominated by the T.U.C. in a conference which aims at removing some of the present barriers to complete co-operation between all branches of industry.

Wills.

WRATHALL, J., retired iron merchant, lately managing director of John W. Laycock, Limited, of Keighley £8,026

MAUDSLAY, W. H., Mawnan, near Falmouth, a member of the old engineering firm of Maudslay, Son & Field, of Lambeth, managing director and chairman of the Birmingham Aluminium Casting (1903) Company, Limited ... £23,084

New Companies.

Brit Engineering Works, Limited, 202, St. Andrew's Road, Bridport, Dorset.—Capital £10,000 in £1 shares. Agreement with C. E. Heinke & Company, Limited. Ironfounders.

Brunswick Engineering Company (1927), Limited.—Capital £450. To acquire business of Brunswick Engineering Company, Limited. Director: F. J. Humphrey. Solicitors: Amery Parkes & Company, 1, Arundel Street, W.C.

Farnley Iron Company (Fireclay Works), Limited, Fireclay Works, Farnley, Leeds.—Capital £100,000 in £1 shares.

W. R. Howard & Partners, Limited, 82, Victoria Street, Westminster, S.W.1.—Capital £10,000 in 5,000 £1 7 per cent. cumulative preference and 100,000 1s. ordinary. Dealers in iron ore, pig-iron, etc. Directors: A. T. J. Gueritte (chairman) and W. R. Howard.

Janair, Limited, 61, Satmore Road, Edgbaston, Birmingham.—Capital £3,000 in 1,500 "A" ordinary and 1,500 "B" ordinary shares of £1. To acquire certain existing inventions relating to casting under pressure and to internal combustion motor locomotives, etc. Directors: W. G. Robson (chairman) and Jan Juel Hagemeister.

Steel Case Compound Company, Limited, 135, Devonshire Street, Birmingham.—Capital £3,000 in £1 shares, to acquire an invention for case-hardening, agreement with A. E. Taylor, F. A. Jones and H. W. Barton.

Company Reports.

British Insulated and Helsby Cables, Limited.—Interim dividend, 2½ per cent.

Allen Everitt & Sons, Limited.—Interim dividend, 9d. per share on ordinary shares.

North Lonsdale Iron & Steel Company, Limited.—No dividend for the year ended October.

Broughton Copper Company, Limited.—Interim dividend, 5 per cent. actual, less tax, on ordinary.

Mint (Birmingham), Limited.—No interim dividend on ordinary shares for six months ended September last.

Power-Gas Corporation, Limited.—Profit, £15,520; transferred to reserve, £3,000; dividend, 5 per cent., less tax; carry forward, £10,145.

David Brown & Sons (Huddersfield), Limited.—Dividend, 2½ per cent., free of tax, on ordinary shares for year; carry forward, £28,382.

Atlas Steel Foundry and Engineering Company, Limited.—Profit, £3,881; brought in, £907; depreciation account, £3,000; carry forward, £1,789.

Bullers, Limited.—Net profit, £15,614; profit and loss, after bringing in amount brought forward, shows available balance, £16,529; £6,460 transferred to sinking fund for redemption of debentures; carry forward, £2,568.

Wrights' Ropes, Limited.—Credit balance, including £9,151 brought in, and after deducting £9,667 for depreciation, £27,378; final dividend on ordinary shares, 5 per cent., making 7½ per cent., less tax, for year; carry forward, £13,628.

Walter Somers, Limited.—Loss, after debenture service (£11,157) and charging depreciation (£18,296), £25,485; deficit brought forward, £177,400; preference dividend, £229; total debit balance, £203,115; dividend on employés' cumulative participating preference, £229.

Contracts Open.

Chadwell Heath, December 17.—(1) 7-in. diam. cast-iron pipes; and (2) 7-in. diam. sluice valves, hatch boxes, portable galvanised pipes, for the Dagenham Urban District Council. The Engineer and Surveyor, Council Offices, Valence House, Becontree Avenue, Chadwell Heath.

Dundee, December 19.—40 fathoms of mooring chain for the Dundee Harbour Trustees. Mr. J. H. Thompson, manager and engineer, Harbour Chambers, Dundee.

Stokenchurch, Bucks., December 21.—840 yds. of 3-in. diam. cast-iron socket and spigot pipes (class B, British Standard specification), together with valves, specials, etc., for the Wycombe Urban District Council. Lucas & Pyke, consulting engineers, 39, Victoria Street, Westminster, S.W.1. (Fee £1, returnable.)

Warrington, December 12.—300 galvanised steel ash-bins and covers, for the Corporation. The Cleansing Superintendent, Central Sanitary Depot, Howley, Warrington.

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Iron and Steel Markets.

Pig-iron.

MIDDLESBROUGH.—Conditions in the Cleveland iron markets during the past week have certainly assumed a more settled appearance than has been experienced for some time, and an increasing volume of inquiries is reported, both on home and overseas account. This improvement in the outlook has doubtless been stimulated to a considerable extent by an impression in market circles that prices have now been stabilised, and consumers consequently have nothing to gain by further postponing forward business. It may be recalled that in October two years ago Cleveland iron was sold as low as 64s., and at that figure business was developing until the Association was reformed and higher prices imposed by agreement. Now, after a period of inflation and bad trade, the market is back to approximately the level of the autumn of 1925. Generally, the Cleveland makers have now moderately healthy order books, and look for a continued expansion of trade. The official quotations to home and foreign buyers are:—No. 1 Cleveland foundry, 67s. 6d. per ton; No. 3 Cleveland G.M.B., 65s.; No. 4 foundry, 64s.; No. 4 forge, 63s. 6d. per ton.

THE MIDLANDS.—Many Black Country foundries having practically suspended buying until after the holidays, the market for pig-iron is only poorly supported, while prices remain about as previously quoted, with Derbyshire No. 3 foundry at 65s. per ton f.o.t., Northamptonshire at 60s., and North Staffordshire at 64s. to 65s. Scotch No. 3 foundry iron is being offered in the Black Country at 90s. per ton delivered, and there is always a small market locally for this quality.

SCOTLAND.—Business in the local markets for pig-iron continues quiet, and with the end of the year in sight a further contraction in the volume of trade is expected. Consumers are buying the smallest quantities possible, and stocks are, in consequence, continuing to accumulate at the makers' works. The price, under these conditions, continues to ease, and 71s. 6d. per ton at the furnaces is the basis for No. 3 Scotch foundry to-day.

The market for East Coast hematite also is not quite so despondent as previously reported, the makers' policy of price-cutting having brought out some fairly substantial orders, and it is now hoped that reduction of output will not be necessary. Nominally, mixed numbers are at 71s. and No. 1 at 71s. 6d. per ton, but a four-figure order could be placed at 70s. On the North-West Coast prices are as low as they can be, having regard to the higher overhead costs, and Bessemer mixed numbers remain at 72s. per ton at works and low-phosphorus iron 2s. 6d. per ton more.

LANCASHIRE.—Local demand for foundry pig, in anticipation of the approaching holiday stoppage, is confined within narrow compass, with prices quoted approximately as follow:—Derbyshire No. 3 foundry, 73s. 6d.; Staffordshire, 72s. 6d.; Cleveland, 78s. 2d.; Scottish, 88s. upwards, all for local delivery.

Finished Iron.

Few transactions in this section of the market have been negotiated by buyers of late, and manufacturers as a rule can only report a very disappointing year's trading. The call for crown and nut and bolt iron at Birmingham is consistently poor, and there is very much competition from the works outside this area to get the limited business offered. It is not possible to secure anything near sufficient orders to warrant anything like regularity in operation, and part-time working at the mills is the rule. Crown iron can be obtained at £9 5s. from certain directions, and the price for this grade of iron varies from that level up to £10 5s., which some of the Staffordshire houses quote. Nut and bolt iron is offered at £8 17s. 6d. to £9 2s. 6d. delivered, but chiefly on account of the Continental competition little support is given in this direction. The improved price for Belgian No. 3 iron is maintained, and quotations to-day are between £5 17s. 6d. and £6 delivered. Staffordshire marked bars remain at £13 at makers' works.

Steel.

As regards home manufactures, except that an easy feeling is still to be observed in the case of steel bars, and a certain amount of easiness also in boiler plates, there is little actual change in the price position of home-produced steels since previously reported. Down to £7 10s. per ton is being indicated in some quarters for small re-rolled bars, with other sizes quoted up to £8 10s. or thereabouts. Boiler plates are on offer at round £10 7s. 6d. per ton, joists and sections at £7 12s. 6d., and ship and tank plates at £8 7s. 6d. Apart from a quiet hand-to-mouth trade in steel that continues to be put through, there is not very much business of importance passing just now, although with numerous inquiries circulating there is a prospect of a bigger demand for the constructional engineering trades early in the New Year.

Scrap.

No improvement can be reported, nor expected, in the markets for scrap metal at this period, and only a negligible amount of business is attempted. At Middlesbrough there is still a fair demand for heavy cast iron and the price is maintained at 66s. per ton machinery quality and 62s. 6d. for ordinary quality. Parcels of heavy steel turnings are readily saleable at 46s. per ton, and there are one or two outlets for cast-iron borings at 43s. per ton. In Scotland, cast-iron scrap is still dull, with a poor demand, and the price is maintained at 67s. 6d. per ton for first-class machinery in pieces not exceeding 1 cwt., and for ordinary heavy cast to the same specification, 5s. per ton less. Old cast-iron railway chairs are not so plentiful and are being quoted at 67s. 6d. per ton, with few buyers. Light cast-iron scrap is still 53s. 6d. to 54s. per ton. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Closing at the week-end nearly a pound higher, the position of warrant copper has been steadily maintained on a progressive scale, with fluctuations mainly tending to a further advance. Consumers are now considered to be fairly well covered for the time being, and it is expected that only small quantities will be purchased until the turn of the year. During the upward movement in values little has been heard of the African and South American production of blister copper, substantial quantities of which will shortly make their appearance in the form of refined copper, and may have some effect on the market in the near future.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £60 10s. to £60 11s. 3d.; Friday, £60 2s. 6d. to £60 3s. 9d.; Monday, £59 15s. to £59 16s. 3d.; Tuesday, £59 10s. to £59 11s. 3d.; Wednesday, £59 5s. to £59 6s. 3d.

Three Months: Thursday, £60 12s. 6d. to £60 13s. 9d.; Friday, £60 5s. to £60 6s. 3d.; Monday, £59 18s. 9d. to £60; Tuesday, £59 13s. 9d. to £59 15s.; Wednesday, £59 7s. 6d. to £59 8s. 9d.

Tin.—Throughout the past week quotations for standard tin were continued on a steadily advancing basis, though business, on the whole, was confined within moderate limits. An interesting feature at the moment is that the backwardation on forward metal has been reduced in spite of the small home stocks, which indicated only a small increase. The improved sentiment was in some measure due to curtailed estimates of the Straits shipments. American buying was well in evidence at one time, both on this side and the East, and the New York market was very firm.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £270 10s. to £270 15s.; Friday, £267 15s. to £268; Monday, £266 5s. to £266 10s.; Tuesday, £265 17s. 6d. to £267; Wednesday, £266 5s. to £266 10s.

Three Months: Thursday, £264 15s. to £265; Friday, £263 5s. to £263 7s. 6d.; Monday, £263 12s. 6d. to £263 15s.; Tuesday, £263 7s. 6d. to £263 10s.; Wednesday, £263 5s. to £263 10s.

Spelter.—The position in the market for ordinary spelter is now becoming more clearly defined, and with returning confidence business has assumed a much steadier tendency. It would seem that the depressed condition of the market for some time past was due more largely to deferred buying by consumers than to either excessive production or diminishing consumption. In any event the fall in prices is providing the necessary corrective, and the market is now beginning to display increasing strength.

The following are the week's prices:—

Ordinary: Thursday, £26 7s. 6d.; Friday, £26 7s. 6d.; Monday, £26 7s. 6d.; Tuesday, £26 2s. 6d.; Wednesday, £26 3s. 9d.

Lead.—This metal is in a slightly better position than was the case a week or so back, both in regard to the market situation and the monthly statistics. Consumers were particularly bare of supplies until recently. The improvement in the price of other metals probably was to some extent responsible for the increased buying of lead, but the heavy purchases by cable interests indicate also a growth of consumptive demand.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £22; Friday, £22 1s. 3d.; Monday, £21 18s. 9d.; Tuesday, £21 18s. 9d.; Wednesday, £22 1s. 3d.

The Washington Hours Convention.

A small pamphlet, entitled "The Washington Hours Convention: A Re-statement of the Facts," has been drawn up by a Joint Committee of the League of Nations Union and the British Section of the International Association for Social Progress, in reply to a document bearing the same title, drawn up by the National Confederation of Employers' Organisations and distributed to the Press and Members of Parliament last June.

The reply contains short historical notes of the Washington Conference, 1919, the Berne Conference, 1924, the London Conference, 1926, and a short summary of the British Government's attitude to the London Conference of February, 1926. It does not attempt to traverse the whole of the 81 points of the National Confederation, but only deals with what it considers to be the main objections. Thus it shows the proportion of British workers who do not work eight hours or under, and disproves the contentions advanced on Collective Agreements and overtime.

The Confederation in its memorandum made a strong point that the French Government when it ratified had no intention of proposing an amendment of any sort whatever to the present law. The joint memorandum sets out categorically statements by the French Minister of Labour at different times and by other French Ministers which prove that the paragraphs of the Confederation memorandum which deal with the French position are not only incorrect but are decidedly misleading. The Federation also says that it is the general custom in French industry not to pay an overtime rate. The joint memorandum gives extracts from relevant collective agreements in French industry which apparently were unknown to the Confederation. In the same way the joint memorandum deals with misleading statements regarding Czecho-Slovakia, Belgium, Italy, Germany, and the United States.

Copies of the pamphlet may be obtained from the League of Nations Union, 15, Grosvenor Crescent, Westminster, S.W.1.

Imports of Copper and Lead and Cast Iron Baths.

The Board of Trade announce that in pursuance of applications received by them for making of Orders-in-Council to require certain imported goods to bear an indication of origin, they have made a reference to the Standing Committee in respect of the following:—

Copper plates, sheets, strips and other rolled sections; rods and wire (other than insulated wire);

Sheet lead and lead pipes, including lead encased pipes and pipes known as compo pipes;

Cast-iron enamel baths of all descriptions.

Attention is called to the fact that, while, under the provisions of the Act, the Committee must in every case referred to them consider whether the goods should bear an indication of origin at the time of sale or exposure for sale, they may also at their discretion consider and report upon the question whether such goods should bear an indication of origin at the time of importation.

Representatives of any interests affected, who desire to be heard in opposition, are requested to communicate with the secretary, Mr. E. W. Reardon, at the New Public Offices, Great George Street, London, S.W.1, not later than December 31.

Sterling

BOXES

STAND UP TO THEIR WORK BECAUSE THEY ARE MADE FROM

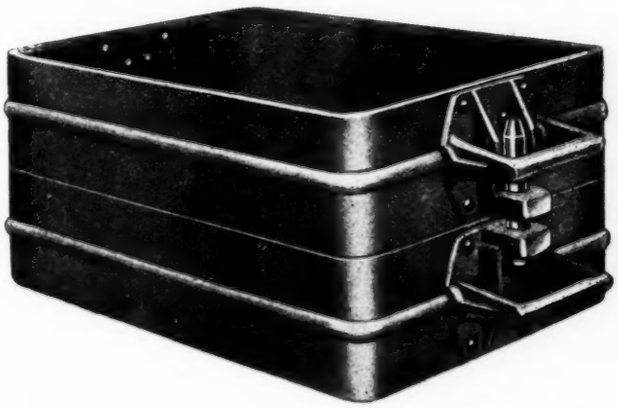
ROLLED STEEL

THEY ARE LIGHT AND EASY TO HANDLE, STRONG, RIGID AND PERMANENTLY ACCURATE.

There is no greater economy you can introduce into your foundry than the

Sterling Rolled Steel Moulding Box

LET YOUR NEXT LOT OF BOXES BE "STERLINGS."



STERLING FOUNDRY SPECIALTIES LTD., BEDFORD

London Office:
13, VICTORIA STREET, S.W.1.

Telephone: 3345 BEDFORD.
Telegrams: "STERFLASK," BEDFORD.
Code: WESTERN UNION.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	59	5	0
Three months	59	7	6
Electrolytic	66	0	0
Tough	64	5	0
Best selected	64	15	0
Sheets	90	0	0
India	75	0	0
Wire bars	66	12	6
Do. December	66	10	0
Do. January	66	10	0
Ingot bars	66	10	0
H.C. Wire rods	70	10	0
Off. av. cash, Nov.	59	17	3 3/11
Do. 3 mths., Nov.	58	18	0 3/4
Do., Sttlmnt., Nov.	58	17	3 3/11
Do., Electro, Nov.	63	19	6 6/11
Do., B.S., Nov.	63	8	7 1/2
Aver. spot price, copper, Nov.	58	17	3 1/4
Do., Wire bars, Nov.	64	3	10 1/2
Solid drawn tubes			12 1/2d.
Brazed tubes			12 1/2d.
Wire			9 1/2d.

BRASS.

Solid drawn tubes	11 1/2d.
Brazed tubes	13 1/2d.
Rods, drawn	10 1/2d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10 1/2d.
Wire	9 1/2d.
Rolled metal	9 1/2d.
Yellow metal rods	7 1/2d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8 1/2d.

TIN.

	£	s.	d.
Standard cash	266	5	0
Three months	263	5	0
English	264	10	0
Bars	267	10	0
Straits	267	2	6
Australian	272	0	0
Eastern	268	0	0
Banca	269	0	0
Off. av. cash, Nov.	262	13	9 15/21
Do., 3 mths., Nov.	258	11	9 3/4
Do., Sttlmt., Nov.	262	13	2 5/11
Aver. spot, Nov.	262	13	9 1/4

SPELTER.

	£	s.	d.
Ordinary	26	3	9
Remelted	26	0	0
Hard	21	0	0
Electro 99.9	30	15	0
English	26	10	0
India	22	10	0
Zinc dust	35	0	0
Zinc ashes	9	0	0
Off. aver., Nov.	26	2	10 12/16
Aver., spot, Nov.	26	5	7 1/2

LEAD.

	£	s.	d.
Soft foreign ppt.	22	1	3
English	23	5	0
Off. average, Nov.	21	2	0 12/16
Average spot, Nov.	20	17	9 1/2

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	35	0	0
Do. V.M. ex whf.	33	10	0
Rods	42	0	0
Boiler plates	30	10	0
Battery plates	32	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	64	10	0
Chinese	41	10	0
Crude	37	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	23	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	8	17	6
45/50%	12	17	6
75%	22	6	0
Ferro-vanadium—			
35/40%	14/3 lb. va.		
Ferro-molybdenum—			
70/75% c. free	5/- lb.		
Ferro-titanium—			
23/25% carbonless	11d		
Ferro-phosphorus, 20/25%	£17	15	0
Ferro-tungsten—			
80/85%, c. fr.	1/3 lb.		
Tungsten metal powder—			
98/99%	1/8 lb.		
Ferro-chrome—			
2/4% car.	£33	15	0
4/6% car.	£23	0	0
6/8% car.	£22	17	6
8/10% car.	£22	5	0
Ferro-chrome—			
Max. 2% car.	£35	17	6
Max. 1% car	£41	12	6
Max. 0.70% car	£53	0	0
70% carbonless	1/4 lb.		
Nickel—99% cubes or pellets	£175	0	0
Ferro-cobalt	9/3 lb.		
Aluminium 98/99%	£105	0	0
Metallic chromium—			
96/98%	2/11 lb.		
Ferro-manganese (net)—			
76/80%, loose	£13	0	0
76/80%, packed	£14	0	0
76/80%, export	£12	0	0
Metallic manganese—			
94/96%, carbonless	1/10 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	£	s.	d.
Finished bars, 14% tungsten	£0	2	6
Finished bars, 18% tungsten	£0	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Hvy. steel	2	19	0	to	3	0	0
Bundled steel and shrngs.	2	12	6	to	2	14	0
Mixed iron and steel	2	12	6	to	2	13	6
Heavy cast iron	2	17	6	to	2	18	6

Good machinery for foundries 3 0 0 to 3 2 6

Cleveland—							
Heavy steel	2	17	6				
Steel turnings	2	6	0				
Cast-iron borings	2	3	0				
Heavy forge	3	12	6				
Bushelled scrap	3	2	6				
Cast-iron scrap	3	2	6	to	3	6	0
Lancashire—							
Cast-iron scrap	3	5	0				
Hvy. wrought	3	2	6				
Steel turnings	2	2	6				

London—Merchants' buying prices delivered yard.

Copper (clean)	51	0	0				
Brass (clean)	39	0	0				
Lead (less usual draft)	20	0	0				
Tea lead	17	0	0				
Zinc	17	0	0				
New aluminium cuttings	76	0	0				
Braziery copper	47	0	0				
Gunmetal	48	0	0				
Hollow pewter	170	0	0				
Shaped black pewter	130	0	0				

PIG-IRON.

(f.o.t. unless otherwise stated.)

	£	s.	d.		£	s.	d.
N.E. Coast—							
Foundry No. 1	67/6						
Foundry No. 3	65/-						
Foundry No. 4	64/-						
Forge No. 4	63/6						
Hematite No. 1	71/6						
Hematite M/Nos.	71/-						
N.W. Coast—							
Hem. M/Nos. d/d Glas.	84/-						
,, d/d Birm.	89/6	to	90/-				
Midlands—							
Staffs. common*	—						
,, No. 4 forge	62/6						
,, No. 3 fdry.	64/6						
Shrops. basic	—						
,, Cold blast, ord.*	—						
,, ,, roll iron*	—						
* d/d Birmingham.							
Northants forge	54/-						
,, fdry. No. 3	60/-						
Derbyshire forge	60/-						
,, fdry. No. 3	65/-						
,, basic	—						
Scotland—							
Foundry No. 1	—						
,, No. 3	71/6						
Hem. M/Nos.	76/-						
Sheffield (d/d district)—							
Derby forge	65/-						
,, fdry. No. 3	68/-						
Lincs. forge	66/-						
,, fdry. No. 3	68/-						
E.C. hematite	85/-						
W.C. hematite	89/6						
Lincs. (at furnaces)—							
Forge No. 4	—						
Foundry No. 3	—						
Basic	—						
Lancashire (d/d eq. Man.)—							
Derby forge	—						
,, fdry. No. 3	74/-						
Northants foundry No. 3	—						
Dalzell, No. 3	100/-	to	102/6				
Summerlee, No. 3	88/-	to	94/-				
Glengarnock, No. 3	88/-	to	94/-				
Gartsherrie, No. 3	88/-	to	94/-				
Monkland, No. 3	88/-	to	94/-				
Coltness, No. 3	88/-	to	94/-				
Shotts, No. 3	88/-	to	94/-				

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.		£	s.	d.
Iron—							
Bars (cr.) nom.	9	15	0	to	10	15	0
Angles	—						
Tees to 3 united ins.	—						
Nut and bolt iron	9	0	0				
Hoops	12	10	0				
Marked bars (Staffs.) f.o.t.	13	0	0				
Gas strip	12	0	0				
Bolts and nuts, ¾ in. × 4 in.	15	5	0				
Steel—							
Ship plates	8	2	6	to	8	7	6
Boiler plts.	10	10	0				
Chequer plts.	10	5	0				
Angles	7	12	6				
Tees	8	12	6				
Joists	7	12	6				
Rounds and squares, 3 in. to 5½ in.	7	15	0				
Rounds under 3 in. to ¾ in. (Untested)	8	0	0				

and upwards

Flats, over 5 in. wide and up	9	2	6				
Flats, 5 in. to 1½ in.	8	2	6				
Rails, heavy	8	2	6	to	8	7	6
Fishplates	12	10	0				
Hoops (Staffs.)	10	10	0				
Black sheets, 24g.	10	2	6				
Galv. cor. shts., 24g.	13	5	0				
Galv. fencing wire 8g. plain	12	10	0				
Billets, soft	£5	17	6	to	6	10	0
Billets, hard	8	2	6				
Sheet bars	£5	12	6	to	5	15	0
Tin bars	£5	12	6	to	5	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2½
Sheet to 10 w.g.	1 3
Wire	1 3¾
Rods	1 3
Tubes	1 8½
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	19.76
No. 2 foundry, Valley	17.25
No. 2 foundry, Birm.	16.00
Basic	18.76
Bessemer	19.76
Malleable	18.26
Grey forge	18.51
Ferro-mang. 80% d/d	90.00
Bess rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	40.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Skelp, sheared steel	1.80
Steel hoops	2.30
Sheets, black, No. 24	2.75
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd., 9 and 10	2.10
Wire nails	2.50
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	—
,, furnace	13/6
Other Districts, foundry	—
,, ,, furnace (basis)	12/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14	box		17/9	
,,	28×20	,,		35/6	
,,	20×10	,,		—	
,,	18¾×14	,,		—	
C.W.	20×14	,,		17/1½	
,,	28×20	,,		—	
,,	20×10	,,		—	
,,	18¾×14	,,		—	
Terneplates	28×20	—	per box basis f.o.b.		

SWEDISH IRON.

	£	s.	d.		£	s.	d.
Bars, hammered, £18 10 0 to 19 0 9							
Rolled Ord.	15	0	0	to	15	10	0
Nail rods	15	7	6	to	15	15	0
Keg. steel nom.	33			to	35		
Faggot steel nom.	22			to	25		
Blooms, according to quality	£8			to	£12		
Pig-iron	£5	15	0	to	£6	0	0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	45%
Water	63½%	40%
Steam	60%	35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.	
Dec. 8	60	10	0	dec. 3/9
,, 9	60	2	6	,, 7/6
,, 12	59	15	0	,, 7/6
,, 13	59	10	0	,, 5/-
,, 14	59	5	0	,, 5/-

Electrolytic Copper.

	£	s.	d.	
Dec. 8	66	10	0	No change
,, 9	66	10	0	,, ,,
,, 12	66	5	0	dec. 5/-
,, 13	66	5	0	No change
,, 14	66	0	0	dec. 5/-

Standard Tin (cash).

	£	s.	d.	
Dec. 8	270	10	0	dec. 10/-
,, 9	267	15	0	inc. 5/-
,, 12	266	5	0	dec. 30/-
,, 13	266	17	6	inc. 12/6
,, 14	266	5	0	dec. 12/6

Tin (English ingots).

	£	s.	d.	
Dec. 8	269	0	0	No change
,, 9	266	0	0	dec. 60/-
,, 12	265	0	0	,, 20/-
,, 13	265	10	0	inc. 10/-
,, 14	264	10	0	dec. 20/-

Zinc Sheets (English).

	£	s.	d.	
Dec. 8	35	0	0	No change
,, 9	35	0	0	,, ,,
,, 12	35	0	0	,, ,,
,, 13	35	0	0	,, ,,
,, 14	35	0	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
Dec. 8	26	7	6	dec. 3/9
,, 9	26	7	6	No change
,, 12	26	7	6	,, ,,
,, 13	26	2	6	dec. 5/-
,, 14	26	3	9	inc. 1/3

Lead (English).

	£	s.	d.	
Dec. 8	23	10	0	No change
,, 9	23	10	0	,, ,,
,, 12	23	5	0	dec. 5/-
,, 13	23	5	0	No change
,, 14	23	5	0	,, ,,

AVERAGE MONTHLY PRICES OF STEEL SHIP PLATES (NORTH OF ENGLAND).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896.....	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 0 0	5 0 0	5 0 0	5 0 0	5 2 6	5 10 0	5 10 0	5 2 6
1897.....	5 10 0	5 10 0	5 10 0	5 7 6	5 2 6	5 2 6	5 0 0	5 0 0	5 0 0	5 0 0	5 7 6	5 10 0	5 5 5
1898.....	5 10 0	5 8 9	5 8 9	5 10 0	5 16 3	5 18 9	5 17 6	6 0 0	6 2 6	6 5 0	6 10 0	6 15 0	5 18 6½
1899.....	6 15 0	7 0 0	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 12 6	7 12 6	7 12 6	7 12 6	8 0 0	7 6 5½
1900.....	8 0 0	8 0 0	8 2 6	8 5 0	8 7 6	8 7 6	8 7 6	8 0 0	8 0 0	8 0 0	7 10 0	7 0 0	8 0 0
1901.....	6 15 0	6 15 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 5 0	6 7 6	6 5 0	6 0 0	6 0 0	6 4 4
1902.....	5 17 6	5 12 6	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 10 0	5 14 7½
1903.....	5 10 0	5 10 0	5 15 0	6 0 0	6 0 0	6 0 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 10 0	5 13 11
1904.....	5 7 6	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 11 10
1905.....	5 15 0	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	6 0 0	6 10 0	7 0 0	7 0 0	6 2 3½
1906.....	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 10 0	7 0 10½
1907.....	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 0 0	7 0 0	7 8 4
1908.....	6 10 0	6 10 0	6 10 0	6 5 0	6 5 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 3 9
1909.....	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	5 15 0	5 15 0	5 15 0	6 0 0	6 0 0	6 0 0	6 0 0	5 18 9
1910.....	6 5 0	6 5 0	6 7 6	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 2
1911.....	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 3½
1912.....	7 3 9	7 5 0	7 5 0	7 12 6	7 15 0	7 15 0	7 15 0	8 0 0	8 0 0	8 0 0	6 18 4	6 15 0	7 14 10
1913.....	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	7 19 0	7 15 0	7 3 0	8 2 0	8 5 0	7 16 5½
1914.....	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 0 0	6 0 0	7 0 0	7 5 0	7 5 0	7 15 0	6 10 0	7 6 3
1915.....	8 0 0	8 10 0	9 0 0	9 10 0	9 10 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	7 6 3	7 10 0	6 14 8½
1916.....	11 7 6	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	10 5 0	11 0 0	9 12 11
1917.....	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 9 2
1918.....	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0
1919.....	11 10 0	14 0 0	14 0 0	14 0 0	17 0 0	17 7 6	17 15 0	18 5 0	18 5 0	18 5 0	19 12 6	21 5 0	16 15 5
1920.....	22 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	24 0 0	24 10 0	24 5 0	24 5 0	23 13 4
1921.....	23 5 0	22 10 0	20 4 0	19 0 0	19 0 0	17 0 0	15 0 0	14 15 0	13 12 0	12 5 0	10 10 0	10 10 0	16 9 3
1922.....	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 0	10 0 0	9 7 6	9 4 0	9 5 0	9 5 0	9 5 0	9 18 4½
1923.....	9 7 6	9 15 0	10 5 0	10 10 0	10 10 0	10 10 0	9 18 9	9 17 6	9 17 6	9 17 6	9 18 6	10 6 10½	10 1 2½
1924.....	10 1 6	9 18 1½	9 17 6	9 17 6	9 19 4½	9 19 4½	10 5 0	10 5 0	10 5 0	9 19 0	9 15 0	9 15 0	9 19 7½
1925.....	9 14 0	9 10 0	9 10 0	9 1 3	9 0 0	9 0 0	8 17 0	8 13 1½	8 7 6	8 5 6	7 16 3	7 14 3	8 15 8½
1926.....	7 12 2½	7 12 6	7 12 6	7 14 4½	7 15 0	7 16 10½	8 2 6	8 4 0	8 4 0	8 12 6	8 12 6	8 16 3	8 1 1½
1927.....	8 17 6	8 17 6	8 11 6	8 7 6	8 6 3	8 5 0	8 5 0	8 3 9	8 2 6	8 2 6	8 5 0	—	8 7 7 11

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